PUBLIC HEALTH

CATECHISM SERIES

PUBLIC HEALTH

COMPLETE VOLUME

SECOND EDITION, REVISED BY

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CONTENTS

PUBLIC HEALTH

WATER

How much Water does the Body require for Healthy Nutrition?

Three and a half to five pints—70 to 100 ounces—in twenty-four hours.

How much of this is derived through Food?

About one-third—20 to 30 ounces.

How much Water is required per Head in—

(*a*) "A Manufacturing Town"?
Ans. 37 gallons.

(*b*) "A Non-Manufacturing Town"?
Ans. 25 gallons.

(*c*) "A Rural Village"?
Ans. 12 gallons.

For what Purposes is Water required?

1. For domestic purposes	. .	12 gallons.
2. General baths	. . . .	4 ,,
3. For water-closets	. . .	6 ,,
4. Unavoidable waste	. . .	3 ,,
		Total, 25 gallons.

This is per head in non-manufacturing towns.

Or take it thus—

1. Dietetic uses,	2	gallons.
2. Cleanliness,	16	,,
3. For Sewers,	9	,,
4. Manufactories,	10	,,
Total,	37	gallons.

What Amount is allowed in the Army?

15 gallons per head.

What Towns require little Water?

Towns where the old-fashioned privies are used—"privy towns"—need much less than water-closet towns. In such towns 9 to 12 gallons per head will be enough.

How much Water would you allow for Animals?

For horses and cows, about 6 to 10 gallons.
For sheep and pigs, about $\frac{1}{2}$ to 1 gallon.

In supplying a Town, what Amount of Water should be aimed at?

50 gallons per head per day.

Give a Classification of Waters.

I. "Wholesome" Waters—
  (*a*) Spring.
  (*b*) Deep well.
  (*c*) Upland surface—*i.e.* uncultivated and unmanured land, as hills and mountains.

II. "Suspicious" Waters—
  (*a*) Stored rain water.
  (*b*) Surface water from cultivated land.

III. "Dangerous" Waters—
  (*a*) River water to which sewage has gained access.
  (*b*) Shallow wells.

Is "Peaty" Water bad?

Not necessarily, but it may provoke diarrhœa owing to its richness in vegetable matters.

Is the Water Supply from Uncultivated Surfaces good?

Yes; it is probably the best means of supply.

In using the "Suspicious" Waters, what should you attend to?

Careful collection, storage and filtration.

What is meant by "Under Drainage" Water?

It is water that has filtered through the soil, and is then collected from drains 3 to 6 feet below the surface. Each acre yields 30,000 to 70,000 gallons yearly.

Would this be a Good Supply?

It often is; but, if it is from "manured arable land," it is not good, though even that may be better than shallow wells. It is best from uncultivated upland surfaces.

Is Rain Water a Good Source of Supply?

No; because—

1. The supply is uncertain.
2. The quantity falling in a given area is too small for the inhabitants.
3. Expense of collecting.
4. Apt to become contaminated by storage.
5. It has a vapid taste.

What is the Average Rainfall in England?

About 32 inches. In London and Edinburgh it is actually about 24 inches.

How much is an Inch of Rain per Square Yard?

4·673 gallons.

How many Square Yards in One Acre?

4840 square yards.

How much is an Inch of Rain per Acre?

3630 cubic feet, or 22,622 gallons; and this is equal to about 100 tons.

How would you estimate the Rainfall as a Source of Water Supply?

Take the rainfall of the three conseeutive driest years.

What happens to the Rain when it falls?

1. Part is evaporated.
2. Part flows off the surfaee.
3. Part soaks into the soil.

How does the Rainfall affect the Tcmpcrature?

One grain of water in being evaporated earries off sufficient heat to raise 960 grains 1° F. This is because water, in being converted into vapour, takes up and renders latent a great deal of heat. When land is well drained, therefore, the country becomes warmer, as there is less water to evaporate.

In what Kind of Districts is the Rainfall greatest?

It is greater in mountainous distriets, and espeeially on the leeward side of a mountain or the side facing the prevailing winds—*e.g.* the hot vapour-laden air from the Gulf Stream, impinging on the Cumberland hills, causes a great rainfall in some districts; so also the West Coast of Scotland is more rainy than the East Coast. The effect of mountains is seen near Ben Lomond, where the rainfall measures 91 inches.

What is the Explanation?

Air is able to hold more watery vapour in suspension the higher its temperature; but the hot air impinging upon the cold mountains is suddenly cooled, and therefore so much of

the vapour which it was, at its higher temperature, holding in suspension is deposited as rain, as at the low temperature it is unable to suspend it. Hence, on one side of a range of mountains there may be fertile valleys, while on the other side there is nothing but a desert—*e.g.* the dry desert of Gobi is caused by the Himalaya mountains.

How would you estimate the Rainfall, say, on the Roof of a House?

Multiply the area by 144 to give the square inches, and this again by the rainfall. To bring this to gallons, multiply by 277·274: or remember that a cubic foot (=1728 cubic inches) is=62·5 lb., and that a gallon is=10 lb.; therefore, a cubic foot is=6·25 gallons: also, 62·5 lb. is 1000 ounces, and this, therefore, is the *weight* of a cubic foot of water.

Do you take the Slope of the Roof into account?

No; just ascertain the flat-space covered by the roof, this is=the joint areas of the ground-floor rooms, *plus* the thickness of the walls and eaves.

How would you calculate the Amount of a Well Supply?

Empty it, and allow it to refill and note the time it requires, and multiply by the size of the well. Regard the well as a cylinder, and the cubic contents of a cylinder is=area of the base × the height. Base is=a circle, and the area of a circle is=twice the diameter × ·7854.

What Disadvantage is present in a Water collected from the Chalk Beds?

It is very hard; but the hardness is only "temporary."

How much Chalk does it hold in Solution?

Every 1,000,000 gallons carry away 1¼ ton of chalk.

What are the Characters of River Water?

It is very like rain water, *plus* impurities from the soil, sewers, etc.

What is the Nature of Lake Water?

It usually closely resembles river water, as lakes are usually fed by rivers.

What is a Potable Water?

It is a water that is fit for habitual use as drink either in its natural state, or after it has been purified.

What are the Sources of such Waters?

Rainfall collected in tanks, natural springs, wells, rivers and lakes.

What are the Purest Waters?

Rain water collected in the open country; river water collected near its source is also very pure; some lakes also supply very pure water.

What is a Hard Water?

Hardness may be temporary or permanent. The former is removed by boiling the water, the latter cannot be so removed.

What is the Cause of Temporary Hardness?

It is caused by the carbonates held in solution in water, which always contains carbon dioxide. When the water is boiled the carbon dioxide is driven off and the carbonates (temporary hardness) thrown down.

How can these Carbonates be demonstrated?

By examining the crust formed inside kettles and boilers. This (carbonate) crust is dissolved by the addition of weak acids, such as vinegar.

What causes Permanent Hardness?

It is due to the presenee of ehlorides, sulphates and nitrates of earthy salts whieh eannot be separated by boiling.

What are the Objections to Hard Waters?

They are not suitable for laundry purposes nor for personal ablution, beeause they require large quantities of soap to produce a lather. Hard waters do not properly extraet the virtues of tea, and they harden vegetables cooked in them.

Are Hard Waters adapted for Drinking?

Yes, if the hardness be not excessive.

How may Hard Waters be softened?

By the addition of "milk of lime." This substanee eombines with the exeess of CO_2 in the water to form a carbonate whieh preeipitates with the original carbonate.

How is the Hardness of Water estimated?

By using a standard soap solution so mueh of whieh is required to produee a lasting lather with the water being tested.

What are the Sources of the Hardest Waters?

Those eolleeted from ehalk, limestone and dolomite regions. The softest of all waters is that derived from rain.

What is the Average Rainfall in England?

It varies from 17-35 inches in the south and east to 30-75 in the north and west. Only a small part of this is available for storage owing to losses by evaporation, percolation, etc.

Give an Idea of the Yield of Rainfall?

Twelve inches per annum over an acre of land would provide 25 gallons daily for thirty people.

What are the Contents of Rain Water near Towns ?

Soot, vegetable debris, carbon dioxide, lead, ammonia, and sulphuric acid.

Is Rain Water used for Drinking Purposes ?

Very seldom. Gibraltar depends upon rain water. It is only when all other resources are either scarce or dangerous that rain water is relied upon.

What is Ground Water ?

Rain soaks into the soil and descends until it meets an impervious stratum. The sheet of water which collects at this region is known as " ground water," and is constantly moving because it follows the inclination of the land.

What is the Nature of this Ground Water ?

It is charged with carbon dioxide, oxygen and nitrogen. Also calcareous salts may yield CO_2 as the water comes in contact with them. Ground air also gives up CO_2 to the water. Ground water near graveyards, cesspools, etc., may feed shallow wells with a rich sparkling water which is in reality highly dangerous.

What is a Spring ?

It is an outcrop of water which may have emerged from the edge of an impervious stratum. The water is held down by an impervious layer, it may be of clay, but as soon as there is a break in the continuity of this layer the retained water forces its way to the surface there to appear as a spring.

What is a Well ?

It is really an artificial spring formed by making an excavation in the ground. Wells are of two varieties, shallow and deep.

What is a Shallow or Surface Well?

It may be of any depth, usually less than 50 feet, and depends usually for its supply upon ground water. No impervious stratum exists between the source of the water and surface of the well.

What is a Deep Well?

It is sunk into the ground beyond the surface soil and through an impervious stratum into a deeper water-bearing one. It contains pure water as a rule, which may be hard and deficiently aerated.

What is an Artesian Well? Name two such Wells.

It is a deep well sunk into the ground the water coming from higher surrounding lands. As soon as the well is sunk the discovered water rises and overflows the edges of the well. Grenelle in Paris, and Kissingen in Bavaria.

Why are they called Artesian Wells?

Because they were sunk in Artois.

What is an Abyssinian Well?

It consists of a series of tubes driven into the ground the foremost pipe being pointed and perforated to admit of water being pumped up to the surface.

Are Rivers good Sources of Water Supply?

Only at their upper reaches, because nearly all rivers receive contamination in the form of sewage. To render river water reasonably safe it must be carefully filtered. London is supplied with filtered river water. In Scotland Perth is similarly supplied. The natural tendency is for river water to render organic contamination inert by oxygenation and through the agency of algæ and fresh-water bacteria contained in the water. Few rivers in this country are sufficiently long to render sewage inert.

Should Sewage be sent into Rivers?

No. The Rivers Pollution Prevention Acts forbid the practice.

What happens to Sewage when it enters a Running Stream?

It may be oxidised or rendered innocuous by—

(*a*) The oxygen contained in the water.
(*b*) The bacteria natural to water.
(*c*) Green plants.
(*d*) Fishes.
(*e*) Dilution.
(*f*) Deposition.

Why are Shallow Wells unsatisfactory Sources of Water Supply?

Because they are often badly constructed and in wrong situations. If they are near old-fashioned privies, middens, piggeries or in close proximity to leaky drains or cesspools, the water in these wells may be seriously contaminated by "organic matters."

Is Water from Uncultivated Land good?

Yes; probably the best.

What Precautions should be adopted in Connection with "Suspicious" Waters?

Careful collection, storage and filtration or, failing the latter, boiling.

Will Filtration purify the "Dangerous" Waters?

Not absolutely, because sand filters are not germ proof.

How may Shallow Waters be rendered safe?

By puddling the walls with clay, covering the mouth of the well and raising its edges to prevent surface washings from gaining access to the well. As an additional precaution the well may be filled with gravel and fine sand so that all water

must pass upwards through the filter thus formed. These precautions would be of little value if dunghills, privies, cesspools, etc., were not removed from the neighbourhood of the well.

What are the best Geological Formations from which "Wholesome" Waters may be collected ?

Chalk formations, oolite, greensand, Hastings red, new red conglomerate sandstone.

What are the Infectious Diseases that may be spread by Water ?

Enteric fever, cholera and dysentery.

Name any other Diseases that may be spread by Water ?

Dyspepsia and diarrhœa, entozoa, embracing the tape, thread and round worms, bilharzia hæmatobia, incephelas dispardistoma hepaticum, anchylostoma duodenale, filaria dracunculus, metallic poisoning.

Should Cisterns be used for storing Household Water ?

Not unless they are absolutely necessary.

Of what Materials should they be constructed ?

Zinc, slate slabs, and galvanised iron ; lead and wooden cisterns are objectionable.

What is the Objection to Lead ?

Certain waters dissolve it to a considerable extent, and this may cause lead poisoning.

How may Lead be removed from Water ?

Removal is effected by filtering through sand, spongy iron or charcoal. Moorland waters which are very acid and therefore prone to act on lead can be prevented from so doing by reducing their acidity to a point below ·5 parts per 100,000, or by making the water alkaline by means of lime and chalk, 80 to 90 grains of lime to the gallon being added.

How may Water Waste be prevented?

By the use of Deacon's Waste Detecting Meters, which indicate the amount of water passing along a pipe.

What are the Special Points to be attended to in regard to Cisterns?

They should be well covered and protected from heat and frost, should be easy of access and periodically inspected and cleaned. They should not be in dark out-of-the-way corners, and there should be a free circulation of pure air round them; and they should themselves be ventilated. They should not be near sleeping attics, over water-closets, nor near ventilating pipes. No water for drinking or cooking should be obtained from the same cisterns as that from which water is directly drawn for the water-closets and sinks; and all unfiltered water stored in cisterns within the dwelling should be properly filtered after it leaves the cistern. It is better to do without cisterns except for the water-closet and kitchen boiler.

What are the Chief Points to be attended to in regard to the "Overflow Pipe" of a Cistern?

It should never open into a sewer or water-closet pipe. It must have no communication with any other overflow or waste soil pipe or drain. It should pass through an external wall and discharge by an open end, some little way above the ground, over a trapped grating; it should not, however, be near an intercepting drain, trap or its grating, because gases are apt to be drawn up the pipe, by the warmth of the house, to the cistern. The end of the overflow pipe should be easily seen so as to detect unnecessary waste. The overflow pipe should be used only as a "warning pipe."

What is the Objection to its Opening on to the Outer Wall or into the Roof Gutters?

It may become blocked up with ice in winter, and therefore be useless, and the water thus overflow into the house.

What are "Waste Water Preventers"?

They are small cisterns holding a definite amount of water, usually 3 gallons, and emptying on the "syphon system." With this apparatus attached to a water-closet pipe only a certain amount of water can flow every time the closet is used. This prevents the water being turned on and left to run indefinitely, as may occur in connection with the objectionable "pan-closet."

What Special Points must be attended to in the Cleaning out of a Cistern?

The cistern must be frequently cleaned out. It should always be cleaned out when, for example, the family returns from summer holidays. It should be cleaned out with a soft hearth brush, lightly rubbed over it and with plenty of water; the sides must on no account be scrubbed with a hard brush, or with sand or anything rough, as this would remove the protective coating over the lead, and expose the fresh bright lead surface to the action of the fresh water, with the certainty that some would be absorbed before another protective coating could be deposited.

Name two reliable domestic Filters.

Pasteur-Chamberland; Berkefeld.

Which of these is the more reliable?

The Pasteur-Chamberland because it is slower in action than the Berkefeld. The former is made of unglazed, porous porcelain, the latter of infusorial clay known as Kiesselguhr. Another filter not unlike the Pasteur is the Porcelain d'Amiante, but it is very brittle.

Mention any other Filters.

The materials that have been employed in connection with domestic filters are vegetable and animal charcoal, silicated carbon, sponge, flannel, spongy iron, magnetic carbide of iron, "carferal," or asbestos.

What Objections are there to Animal Charcoal?

It must be specially prepared and well burned and it may yield nitrogen and phosphates to the water. It is not germ proof.

What are its Good Points?

It oxidises organic matters in water and frees water of lead.

What is Bischof's Filter?

It depends for its efficacy upon spongy iron. This filter is too complicated and has iron and manganese entering into its composition. It removes organic matter from water, lessens hardness and may reduce nitrates to ammonia.

What is Magnetic Carbide of Iron?

It is a carbide of iron pulverised and mixed with sand, the carbide being obtained by roasting red-hæmatite and sawdust together in a retort.

What is Carferal?

It consists of a mixture of iron, charcoal and clay.

What is Maignen's Filtre Rapide?

It is a combination of charcoal, lime and asbestos.

Of what Value are Permanganate of Potassium and Alum for the Purification of Water?

The former may destroy effluvia and can remove much of the dissolved and suspended organic matter. Water so treated must have alum added to it and be subsequently filtered to get rid of the colour of permanganate. Alum alone only helps to clear muddy water.

What is the usual Construction of Water Mains?

Iron pipes protected by either Dr Angus Smith's varnish or Barff's process.

What are these Proeesses ?

Angus Smith's varnish eonsists of pitch free from naphtha, asphalt, oil and tallow. In this boiling mixture iron pipes are dipped. Barff's proeess eonsists in heating the pipes to be treated to a white heat and then playing superheated steam upon them. In this way a magnetic oxide coating is formed on the pipes.

What is meant by the Hydraulic Mean Depth ?

It is the seetional area of a stream divided by the melted perimeter—that is, the bottom of the stream and the parts of the banks whieh are in eontaet with the water at the point where the diseharge is being caleulated.

What is a Rheometer ?

An apparatus not unlike an anemometer and used for caleulating the yield of streams.

What are Pitot's Tubes ?

Used for aseertaining the velocity of streams.

Is there any other Method by which Water on a Large Scale may be filtered ?

By using Bell's filters, or Candy's filters. These are steel eylinders filled with fine sand, the water to be filtered being forced through the sand. To clean the sand revolving arms are fitted inside the steel eylinders, the current of water being reversed through the sand to complete eleansing operations.

How may the Yield of a stream be estimated ?

By the method known as weir gauging, or by employing floating bodies. The former is the more aeeurate method.

In regard to the Placing of Water Pipes, what should be attended to ?

They should not be fixed on the outer faee of an external

wall, nor yet even upon the internal face, especially walls facing north or east, unless well cased and protected from frost.

What is the Best Protective?

Probably a box filled with cocoa-nut fibre; sawdust decays, and hair-felt rots.

In Cases where the Supply is constant, what Fitment should be between the House Pipes and the Main?

A good "screw-down" tap should be placed at the entrance of the pipe into the house, and this tap should be in charge of the tenant.

Why?

So as to enable the tenant to turn the water off should the pipes burst, and to empty them during frost.

Why do Householders usually state that it is the Thaw that bursts the Pipes?

Because it is only when the thaw comes and the ice begins to melt that the crack is discovered, as, of course, ice won't flow through a crack; but when the thaw comes the ice plugging the crack is displaced and water flows through.

Explain the Bursting of Pipes during Frost.

It is due to the fact that water, in freezing, *expands* a little, so that a cubic inch of ice occupies a greater bulk than a cubic inch of water at the same temperature, and as the lead cannot "give" enough, of course it bursts.

Why are Lead Pipes so much used in Houses?

Because they can be conveniently twisted round bends and corners.

What is the Chief Objection to their Use?

Because water acts on the lead, specially if the water be

highly oxygenated or contains much organic matter. Also lead pipes can be readily damaged.

Mention another Way in which a Lead Pump might be dissolved in Well Water.

Even in "hard" waters, the part of the pump not actually under cover of the water may be acted on thus: the water evaporates from the surface of the well and fills the space above with watery vapour, but this, in contact with the cold lead condenses, as fine drops of *pure* water, and this *pure* water dissolves a little of the lead and drips back into the well.

What Openings should there be in Pipes conducting Water to Towns?

There should be "scouring valves" in valleys, so as to get any sediment cleared out, and also taps at every half mile or so to permit of repairs; also valve cocks at the summits of hills and eminences, to let out air should it collect in the pipes.

Why is Air in Pipes objectionable?

Because a comparatively small quantity will almost stop the flow in pipes, unless the water is under great pressure; and besides, it might be carried to the house pipes, where this is far more likely to happen.

Give an Example of this.

The connecting pipe between two cisterns must "not be bent upwards," it must either be horizontal or bent downwards, otherwise water won't flow through unless under great pressure, should there be a bubble of air in the pipe; the air, of course, goes to the highest part and sticks there, and effectually prevents the flow.

What about the Position of the Street Pipes?

In wide streets, or where there is much traffic, there should be a service pipe at each side, to make the house pipes as short

as possible, and to be accessible without disturbing the traffic. The water pipes, also, should be as far apart as possible from sewers and gas pipes, as the risk of " suction " from leaky mains is very great, especially where the " intermittent system " is in use.

What about the Depth of the Street Pipes ?

If deeper than the gas pipes and sewers, they are less likely to absorb " gases," as gases of course always tend to rise ; but, on the other hand, liquid matters from the sewers percolate downwards. If the sewers do not leak, then the water pipes should be placed below the level of the sewers and gas pipes.

What is meant by the " Intermittent " and " Constant " Supply ?

In the " intermittent," the water from the reservoir is only turned on certain days of the week, or at certain hours of the day, thus necessitating the employment of a cistern containing three days' supply. In the " constant " system the water is always turned on, and no cistern is required in the house except for water-closets, sinks and kitchen boilers.

What are the Objections to the " Intermittent " System ?

1. The chance of contamination is great.

2. There is often imperfect means of storage and the mere fact of requiring a " store " is bad. The necessity of supplying cisterns also increases the expense ; but the chief objection is the great risk of rendering the stored water impure, as the cistern is usually badly placed so that it cannot be cleaned, gases are absorbed, dust and mice fall into the water.

How may the Water be contaminated in the Pipes by the " Intermittent " System ?

When the pipes and mains are empty of water, especially if the joints be badly fitted or if there be holes in the pipes foul air is sucked in and fills the pipes and mains, and when next the water is turned on these gases are absorbed and carried to

the houses; also if near leaky sewers, foul water may enter the water pipes through leaky joints or holes.

What are the Disadvantages of the "Constant" System—

(*a*) To Consumer?
(*b*) To Water Company?

The objections to this system are only removable failures, there is no chance of contamination except in the pipes or reservoir. The disadvantages are—

(*a*) To Consumer.—There are none if there be "abundance" of water, as at Glasgow; but if it has to be economised it is often shut off, and the houses get none for hours, though this is usually done at night.

(*b*) To the Company.—The "constant" system, it is said, is apt to lead to great waste of water for bad fittings, fraudulent abstraction of water, the fittings stolen and a great waste before the theft is discovered. All this can be remedied by effective control and proper appliances.

What are the Means to be adopted to prevent Waste?

1. See that the fittings are good, with the best "screw" taps.
2. Make the theft of fittings a specific offence punishable by imprisonment.
3. Careful inspection by the Company's Officers.
4. Allow no water pipe or waste to open anywhere where the end of the pipe cannot be easily seen, so that waste could be easily detected and prevented.

Name Towns supplied by each System.

The "Constant"—

Glasgow, Perth, Birmingham, Eastbourne and Wigan.

The "Intermittent"—

Edinburgh, Bath, Oxford and Tunbridge Wells.

What are the Causes of Waste in the "Constant" System?

1. Escape between the main and the house.
2. Careless consumption or wilful abuse. To check this the Company's Officers must supervise the taps and pipes, or waste preventers may be introduced; the Company has also power by Act of Parliament to enter houses and see that there is no waste, and can also repair fittings at the expense of the tenant.
3. Waste from improper apparatus and fittings. All fittings should be examined before they are fixed.

What are the Usual Forms of Taps?

1. The plug tap, like the tap of a gas jet.
2. The screw-down tap.

When may either the One or the Other be used?

The plug tap shuts off the water by a single half turn, is therefore rapid, and does very well in the intermittent supply system, and also in pipes for cisterns. On the constant system use the screw-down tap.

Which kind of Supply is best for the Poor?

The "constant" system, as there are no cisterns to clean; but it should deliver sufficient water at *all* times, and must be distributed to every house and every flat of the house.

What should be the Size of the Water Pipes in the House?

In the "constant" supply pipes, half to one inch in diameter.
In the "intermittent," one and a half to two inches.

How do you calculate the Discharge from Pipes?

First find the velocity of discharge:—

$$\frac{\text{Head} \times \text{diameter of pipe}}{\text{Length of pipe}}$$

All in feet. Take the square root and × result by 50, and the result is = velocity in feet per second ;

and

velocity × the area of the pipe, in feet, = the number of cubic feet discharged per second ;

and

this × 6·25 = the number of gallons.

[Area of pipe = $D^2 \times \cdot 7854$.]

Give an Example of this.

Head, 32 feet.

Diameter of pipe, $\frac{1}{2}$ foot.

Length of pipe, 100 feet.

$$\frac{32 \times \frac{1}{2}}{100} = \cdot 16.$$

Square root of ·16 = ·4 and 4 + 50 = 20.

Velocity therefore is = 20 feet per second.

Let the sectional area be = one-fifth of a foot.

Then $20 \times \frac{1}{5} = 4$

Discharge therefore = 4 cubic feet ;

and

$$4 \times 6 \cdot 25 = 25.$$

That is 25 gallons per second : this is in straight pipes.

What is the Effect of Friction and Bends in Pipes ?

The effect of " friction " is = " loss of head " ; the flow is retarded and the water will not spout up to the same height as the source ; the effect of friction is greater the smaller the pipe.

" Curves " retard the flow very much. In an angle of 40° " loss of head " is = one-seventh of the original head.

An angle of 60° it is = one-third.

An angle of 90° it is almost = the original head.

In such cases the water will not rise so high as the original head, IF IT CAN GET OUT BEFORE ; but still, if conducted in a pipe, it will rise to the original height.

What is the Composition of the Protective Film formed?

Carbonate and hydrate of lead with some phosphate and sulphate; also some carbonates, phosphates, and sulphates of lime and magnesia along with organic matters. It is this covering that must *not* be removed in cleaning out lead cisterns.

Name other Conditions in which Lead is very apt to be dissolved in Water.

It is much more easily acted upon if galvanic action be set up from the presence of dissimilar metals, as iron, zinc or tin, as lead pipes containing a certain proportion of zinc or *vice versa*, or lead pipes lined with tin, and the tin cracking and allowing the water to reach the lead. Bending lead pipes against the grain is also bad.

What Amount is required to cause Poisoning?

Any quantity over one-twentieth of a grain per gallon, as a general rule, but apparently a less quantity has been known to cause poisonous symptoms.

In a Household, who are usually the First to be effected by Lead Poisoning, and why?

The servants; because in the morning they draw and use the water that has been standing in the pipes all night, and for this reason likely to contain a greater proportion of dissolved lead.

How can Lead most Easily be Detected?

By means of sulphuretted hydrogen; the water is placed in a tall glass jar, and then the observer looks *down* the jar against a sheet of white paper.

What are the Characteristics of a Good Water Supply?

1. It must be of sufficient "quantity."
2. Of good general "quality."
3. It must be filtered.

4. It must be supplied at all hours of the day and night—*i.e.* on the "constant" system.

What are the Characteristics of Pure and Wholesome Water?

1. It should be transparent, without suspended matters, without smell or taste, well aerated, and preferably without colour—although peaty water may be yellow.

2. The total solids should not exceed 8 grains per gallon, of which only 1 should be dissipated by heat—unless it be in "chalk water," which may be allowed to contain 14 grains per gallon of calcium carbonate, but only traces of the sulphate.

3. Matter destructible by heat should be under 1 grain, and should scarcely blacken—allowance must be made for the decomposition of calcium carbonate.

4. Reaction for nitrates, absent.

5. Reaction for nitrites and free ammonia, very slight.

6. "Albuminoid ammonia," not more than ·0056 grains per gallon.

Water with a slight increase in the above quantities may still be reckoned as "usable" though not pure water. It should be sparkling from the presence of dissolved gases—carbonic acid and atmospheric air. Small print should be read through a depth of 2 feet.

What Substances ought specially to be absent from Drinking Water?

1. Nitrites.
2. Nitrates.
3. Ammonia and its salts.
4. Metallic salts.
5. Much organic matter.
6. Alkaline sulphides.
7. Sulphuretted hydrogen.

What are the Characteristics of Rain Water?

It is almost as pure as distilled water—it is "natural"

distilled water, though it is apt to take up gaseous and suspended solid matters in its passage through the air, as ammonia salts, nitrous and nitric acids, and in some towns sulphurous and sulphuric acids, and sulphuretted hydrogen; but the amount and kind of materials thus taken up depends entirely on the state of the atmosphere: its taste is vapid and unpleasant; it is very soft, and therefore is much used for washing purposes, as it destroys less soap and it is also good for making tea. It is highly aerated, thus—

Carbonic acid	2·5 per cent.
Oxygen	35·0 „
Nitrogen	62·5 „

It may take up lead or zinc from the surfaces on which it falls.

Does it make a Good Water Supply?

It is good because of its purity and aeration, but as a supply it is bad as it is too uncertain, and large reservoirs are necessary, and the water thus kept is apt to be contaminated.

Under what Conditions may it be used with Advantage?

1. Where other sources are deficient.
2. It may also be used with advantage during outbreaks of diseases spread by other sources of water supply—*e.g.* wells, rivers or lakes.

What are the Features of Ice and Snow Waters?

In freezing, water becomes much purer, the salts and air being almost all got rid of; when melted, therefore, ice water is fairly pure, but heavy and non-aerated. Snow water contains the salts of rain water, with the exception of rather less ammonia the amounts of carbonic acid and air are very small: otherwise it resembles rain water. The taste, however, is not pleasant.

What other Varieties of Water Supply are there?

Shallow Wells.—These often contain much organic matters (12 to 30 grains), and are not usually constant.

Deep Wells and Springs.—In this case any organic matters the water might at one time contain, are oxidised into harmless mineral compounds : the water is also as a rule " hard," as, in its course through the soil and various deep strata, it becomes impregnated with carbonic acid and takes up a good deal of salts of very various kinds, especially lime salts. Artesian wells often contain large quantities of the alkaline carbonates and sulphates of lime.

River Water is softer than spring and well water, and usually contains less mineral matter, but its composition is very complex, and varies with season—*e.g.* summer or winter : it may also be contaminated with sewage, but as a rule river water is fairly pure. Some springs and wells contain so many saline ingredients that they are only used for medicinal purposes, and are known as " mineral waters."

Lake Water resembles river water, as lakes are fed by rivers, but may contain much vegetable organic matters from their being stagnant.

Marsh and Upland Moor Waters always contain a large amount of vegetable organic matters—12 to 40 grains or more : often much suspended organic matters ; salts are usually scanty—unless the marsh be near the sea—and consist of the carbonates, sulphates and chlorides of sodium, and calcium.

What is Distilled Water?

It is water transformed into steam, or vaporised, by the aid of artificial heat, and then condensed into water again by the aid of cold : in short, it is vaporisation *plus* condensation.

Where is this Method frequently adopted?

At sea, as it affords an easy way of getting good water from salt water, since the salts do not rise with the steam.

What is the Special Objection to the Water?

It is not properly oxygenated, and therefore flat, insipid and very unpalatable.

How can this be overcome?

By allowing it to flow through a cask at some height, the bottom being pierced with fine holes to expose the water to the air.

What other Precautions should be taken?

To see that lead is not dissolved in the water, from the use of lead pipes in the distilling apparatus or from zinc pipes containing lead in their composition..

What is an "Impounding" Reservoir?

It is a reservoir formed by throwing a dam across a valley through which a stream flows, and thus forming an artificial lake.

What Methods are used to purify Water?

1. Distillation.
2. Boiling.
3. Filtration.
4. Addition of Chlorine.
5. Ozone.

Does Distillation completely purify Water?

It gets rid of solid impurities, but not of carbonic acid, ammonia, or other volatile bases.

What is the Usual Plan of Filtering Water?

The water is first collected into large settling tanks and then filtered by descent. The filters consist of tanks open to the air, at the lower part of which the filtering layers are placed; the filter proper being usually from 3 to 5 feet in depth. The upper two feet or so consists of sand; the lower three, coarse

gravel, becoming coarser and coarser as we pass down. The sand should be sharp and angular and not too fine.

What Rate should the Water pass through the Filter?

From 70 to 75 gallons each square foot of surface in twenty-four hours, or 700 gallons per square yard.

How does a Filter like this act?

The action is almost entirely mechanical. It acts by—

1. Straining.
2. Removal of matters by adhesion to the sand.
3. Subsidence within the interstices of the filter itself.

It removes suspended matters, but only about 5 per cent. of dissolved organic matters. As the action is mechanical chiefly, it is therefore necessary to clean it occasionally, and how often will depend on the nature of the water to be filtered.

How would you clean it?

By removing half-an-inch or so of the sand on the top, as this is the active part. The sand removed is then washed, carefully cleaned, and may then be used over again.

In what Forms may Nitrogen be found in Water?

In any form, starting from fresh sewage matter, up to the fully oxidised products, nitrates—as sewage matter, containing nitrogenous organic matter when exposed to oxygen, especially in the soil, undergoes a gradual oxidation.

Name the Different Steps of this Oxidising Process.

Starting with fresh sewage matters, we have :—

1. Organic matter, containing nitrogen; this is partially oxidised, and we then get
2. "Albuminoid ammonia." Still further oxidation gives
3. Fully or "ready formed ammonia." The next step gives

4. Nitrous acid and nitrites; and lastly, with full oxidation, we have

5. Nitric acid and nitrates.

What is the Supposed Cause?

Nitrification is believed to be due to the action of minute micro-organisms.

Are Nitrates in themselves harmful?

No; they are perfectly harmless.

Why then is Water condemned when the Reaction for Nitrates is well marked?

Because although "nitrates" are harmless, yet their presence points to their source, which is probably sewage matters finding their way into the water.

Would the Presence of Nitrates make you condemn every Water?

No; nitrates in water coming from deep chalk beds have no such significance, as their source, the protoplasmic bodies that once occupied the minute shells of which chalk is composed, have all been completely oxidised long ago into the harmless nitrates.

Whether would Nitrates or Albuminoid Ammonia in Water be of more serious Significance?

The "albuminoid ammonia," as it is three or four steps nearer the original source of contamination, and to this extent imperfectly oxidised.

If Ammonia only is found in Water, what is its Significance?

If ammonia alone be found in an otherwise clear and pure water, without nitrites, nitrates or chlorides, it is probably derived from rain or "vegetable" organic matters; but if, with the ammonia, there be nitrites and chlorides in excess, it

shows that the water is polluted with animal organic matters and is not fit for use.

What is meant by the "Hardness" of Water?

Waters are called hard or soft according to the effect they have on soap. When water lathers easily, it is said to be "soft"; but when with difficulty it is called "hard."

Explain this?

A water only lathers freely when all the dissolved saline constituents are decomposed, and this has first to be done by the soap: the soap as it were is first decomposed, the fatty acid thus set free, uniting with the bases in the water, forming oleates, stearates, or palmates of lime and magnesia, and the alkali of the sap uniting with the acids of these bases; then, after the acids and bases are thus rearranged, the water begins to lather easily.

What is meant by "Degrees of Hardness"?

There are two meanings:—

1. Wanklyn's.—Here it means the number of parts or measures of a standard soap solution consumed by a gallon of water, in yielding a permanent lather, each measure—say a cubic centimetre—representing one degree of hardness.

2. Clark's.—In this case it means the number of grains of the carbonate or sulphate of lime, or its equivalent of other soap-destroying salts, in a gallon of water; a degree of hardness, therefore, corresponds to one grain of soap-destroying salts in a gallon of water, and not as the last to the quantity of soap which a gallon of water will destroy.

How much Soap does a Degree of Hardness destroy?

About two and a half ounces of soap in each 100 gallons of water, used for washing purposes, each grain of carbonate of lime destroying ten grains of soap.

Name another Objection to Hard Water.

It crusts boilers, and thus more fuel is wasted in heating the water.

What would you call Soft and Hard Water?

3 to 4 degrees of hardness is very soft.
8 to 10 degrees moderately hard.
20 + very hard.

At or below 6 may be called soft, above this hard.

What Proportion should exist between Temporary and Permanent Hardness?

If the total is 15 degrees, then of this about 10 or 12 should be temporary, and the rest permanent.

Give a Classification of Waters according to "Hardness."

1. Rain water (softest).
2. Upland surface.
3. Surface water from cultivated land.
4. Polluted river.
5. Spring.
6. Deep well.
7. Shallow well (the hardest).

What Process requires very Hard Water?

Brewing. In this case the water may contain as many as 28 or 30 degrees of "permanent" hardness to the gallon—from calcium sulphate—*e.g.* at Burton-on-Trent.

Why is this?

The hard water keeps out the colouring matter of the malt.

Why is River Water hardest near its Source?

It is often very hard near the beginning, but as it flows on the agitation caused by its flow over the stones gets rid of so much of the carbonic acid, and a part, therefore, of the lime

salts is deposited on the stones, and thus the water becomes softer.

What Domestic Plan is used to soften Water?

By putting a marble into the kettle; this, during the boiling, rolls about, agitating the water, and helps to drive off the carbonic acid. It also lessens the deposit or "fur."

What Means could be adopted to soften Water?

1. Lime may be used.
2. Carbonate of soda may be used.
3. Soap may be used.

What other Processes are there for softening Water?

Porter-Clark's, which is a modification of Clark's, and consists of removing the precipitate by filtration through canvas or cloth instead of permitting sedimentation. The alum process softens hard waters by a combination of the alum with calcium carbonate to form an insoluble calcium sulphate and aluminic hydrate. Howatson's process attempts to remove both temporary and permanent hardness by the addition of caustic soda and slaked lime. Marquen's process consists in the addition to the water to be treated of a mixture of lime, alum and sodic carbonate.

What are the Causes of Deposits in Steam Boilers?

1. The driving off, by boiling, of the free carbonic acid, and consequently the salts it held in solution are deposited.

2. The gradual concentration of the water, so that it is unable to hold the salts any longer in solution.

What are the Disadvantages and Risks of these Deposits?

1. As the bottom of the boiler (next the fire) becomes thickly coated, much more coal must be used to keep up the steam; hence this is wasteful, and entails more expense.

2. The boiler plates are allowed to become red hot, as the

water cannot reach the lower ones, and this leads to rapid corrosion and wearing away of the plates and weakening of the boiler.

3. The deposit or crust may crack, and allow the water suddenly and directly to reach the red-hot plates, and this is followed by a very rapid generation of steam, and probably bursts the boiler.

How are these Risks to be prevented?

1. Soften the water by Clark's method before it is used to feed the boiler.

2. Introduce some light matter into the boiler, to act mechanically and keep the water in constant and violent motion, and thus prevent deposits from taking place, and then blow out the boiler frequently, thus getting rid of the granular debris.

3. Add ammonium chloride to the water: in this case a decomposition takes place, the lime and magnesium salts become transferred into the very soluble chlorides, while the carbonic acid and free ammonia are driven off with the steam.

What is the Objection to this last Plan?

The ammonia acts on the brass and copper fittings.

Describe Clark's Process for softening Water?

The water is collected into large tanks and treated with as much lime water as will neutralise the free carbonic acid present, forming carbonate of calcium which is then precipitated with the carbonate of lime previously dissolved in the water; this gradually settles at the bottom, and in doing so carries down a large amount of the organic matter present. This plan may be used to soften water for paper mills or other manufactories; and also for town water supplies. The quantity of lime added is 1 oz. to 100 gallons for every degree of temporary hardness.

What are the Chief Objections to Clark's Process?

1. It requires large extra reservoirs when done on the large

scale, as large volumes of water have to be left at rest for many hours ; this, of course, entails extra expense.

2. The great quantity of chalk that accumulates at the bottom of the reservoirs, and that must be carted away occasionally, also entails extra expense.

3. The softened water is more likely to attack lead pipes.

EXAMINATION OF WATER

How much is required for a Complete Examination ?

From half-a-gallon to a gallon.

What Precautions have to be observed in collecting it ?

The vessel must be very carefully cleaned ; an ordinary glass-stoppered Winchester quart (= about half-a-gallon) is usually used. In a lake or pond, take the sample at some distance from the bank, and also at some distance below the surface, so as to avoid scum and yet not disturb the mud at the bottom. In towns, take it from mains or stand pipes. In a river, take it from the centre, avoiding outlets of sewers or feeders.

What Gases are usually found in Water ?

Oxygen, nitrogen, and carbonic acid ; sometimes marsh gas (in marsh water), and sulphuretted hydrogen.

What Amounts are usually present ?

Oxygen, about 32 per cent. ; but the amount of this gas, as well as of carbonic acid, depends on exposure to air, and on the presence or absence of plants and animals and organic matters.

What Effect is likely to be produced by Organic Matters ?

The oxygen decreased, and the carbonic acid increased : the amount of nitrogen is usually constant.

How are the gases estimated ?

By means of a mercurial trough, a graduated glass tube

filled with mercury and inverted in the trough, a flask and connecting tube. The water is put into the flask and gently boiled for about an hour, and the gases are thus driven off and are collected in the graduated glass tube.

How are the three Gases separated?

The " carbonic acid " is absorbed by caustic potash.
The " oxygen " by pyrogallate of potassium.
The " nitrogen " is read as the residue.

What are the Objections?

1. Heat decomposes the carbonates.
2. It is impossible to get all the nitrogen and oxygen by this method.

How is Sulphuretted Hydrogen detected?

1. By its smell = " rotten eggs."
2. By a solution of the acetate of lead allowed to flow gently over the surface of the water = " black streaks."
3. By a solution of the nitro-prusside of sodium, having first added a little caustic soda, as it only acts on sulphides = " a violet purple colour."

What is the Origin of this Gas in Water?

From the de-oxidising influence of decaying organic matter on the various sulphates present; the sulphur and the hydrogen unite to form the gas in question.

How do you detect Recent Sewage Contamination?

By the " rapid " discolorisation of a solution of potassium permanganate; this would show the presence of much fresh organic matters, most likely from sewage.

What are the Fallacies of this Test?

Must first make sure of the absence of sulphuretted hydrogen, ferrous salts and nitrites, as these substances would also very quickly decolorise the solution.

What is the Strength of the Solution ?

Two grains to ten and a half ounces of distilled water ; ten minims of this = one-thousandth grain of oxygen.

What do you do before adding the Solution ?

Acidulate the water with a few drops of hydrochloric acid.

How long should the Colour remain if the Water be pure ?

For at least five minutes ; if gone before this time, more must be added till the colour is pretty permanent : the amount required and the rapidity of decolorisation will indicate the nature and amount of the organic matters present.

What is the best Temperature for this Test ?

The whole process should be carried on at a temperature of 140° F.

How do you estimate the Total Residue or " Total Dissolved Solids " ?

By carefully evaporating a pint (20 ounces) of the water to dryness, and then heat for some time at 150° C., until the residue ceases to lose weight : this = the amount of the " total dissolved solids."

What is to be done next ?

Heat the above to redness for a few seconds, and weigh again.

What does this give you ?

The loss of weight is = the mount of " volatile residue."

Of what does it consist ?

Destructible organic matters, nitrites, ammoniacal salts, and sometimes chlorides.

What remains after the Volatile Residue is driven off ?

The " saline residue," consisting of the dissolved salts of lime, magnesia, etc.

What Amount of Saline Residue should there be?

Not less than 3 or 4 grains or more than 12 to 15 grains per gallon.

It will be observed, therefore, that the "total dissolved solids" consist of :—

(*a*) The volatile residue.
(*b*) The saline residue.

In heating the "Total Residue," how do you roughly judge of the Kind and Amount of Organic Matters?

1. Smell.—A smell of "burnt feathers" indictates *animal* organic matters. A smell of "burnt bread" indicates the presence of *vegetable* organic matters.

2. The Degree of Charring.—Organic matters always char when heated :—

3 grains per gallon causes some blacking.
6 ,, ,, causes a good deal.
10 ,, ,, causes very marked blacking.

3. Detect nitrous acid (from the nitrites) by means of ozone paper, or paper impregnated with iodide of potassium and starch ; this is moistened and held over the fumes arising from the crucible.

How do you estimate the Chlorine?

A measured volume of water is put into a white porcelain basin, and to this is added a few grains of neutral potassium chromate till the solution is slightly yellow. A graduated solution of nitrate of silver is then dropped in from a burette till a distinct and permanent red or brownish-red colour is produced. As a certain amount of the silver solution corresponds to a given volume of chlorine, the extraction of the amount present is a simple rule-of-three sum.

What is the Use of the Potassium Chromate?

It is to serve as an indicator, to show when the chlorine has all combined with the nitrate of silver ; the silver rather com-

bines with the chlorine present, but the moment that is all used up it attacks the chromate, giving the distinct reddish-brown colour of the chromate of silver.

How can you roughly judge of the Amount?

1 grain per gallon gives a haze.
4 ,, ,, gives marked turbidity.
10 ,, ,, gives a well marked precipitate.

If there is much Chlorine present, what do you infer?

That it comes from :—

1. Strata containing chlorides of sodium or calcium.
2. Admixture with sea-water.
3. Liquid excreta of men and animals.

How do you differentiate these Sources?

In the first two cases there is a great absence of oxidisable or oxidised organic matters, although there is much chlorine present. If from liquid excreta, there is also present ammonia, nitrites, and nitrates, and probably also a good deal of oxidisable organic matters, and probably also phosphoric acid.

NOTE.—If nitrates markedly present and the water has little action on Condy—"old or previous" sewage contamination. But if there be nitrites, ammonia, etc., and it has much action on Condy's fluid, it shows "recent" sewage contamination. So also if there be much chlorine *plus* oxidisable organic matters, it indicates recent sewage impregnation.

How are Nitrates detected?

1. By brucine solution and pure sulphuric acid. Pour the acid down the side of the tube, so as to form a layer at the bottom, under the mixed water and brucia solution. A pink and yellow zone is found where the liquids meet, if nitric acid or nitrates be present.

2. Concentrate the water, and add a mixture of sulphuric acid and indigo ; if nitrates be present, the blue colour disappears.

3. Concentrate the water—twenty ounces to about one ounce—mix with an equal volume of ferrous sulphate, then pour pure sulphuric acid carefully down the side of the tube, so as to form a layer at the bottom. If nitric acid or nitrates be present, a dark brown ring will be formed at the point of junction of the two liquids.

4. Add sulphuric acid to the water, and then drop in a solution of pyrogallic acid ; this will give a pink and blue colour, if nitrates be present.

If Nitrates alone are found in the Water what does it probably indicate ?

That it is due to the presence of nitrates of potassium or sodium, or that it has come from animal substances of long anterior date—*e.g.* the protoplasm of the foraminifera during the formation of the chalk beds.

How is Ammonia detected ?

By Nessler's solution (see after).

What is the Test for Nitrites ?

Add a solution of iodide of potassium and starch to the water, and then add sulphuric acid ; if nitrites be present, this should give an " immediate " blue colour.

What Precaution should be taken?

Make sure that the iodide does not contain any iodate.

How are Sulphides detected ?

By nitro-prusside of sodium ; this should give a violet purple colour.

Does this distinguish between Sulphides and Sulphuretted Hydrogen ?

Yes, because it does not react with uncombined sulphuretted

hydrogen. A black colour with lead, but no colour with the nitro-prusside, shows that the sulphuretted hydrogen is uncombined.

What is the Test for Lime?

Oxalate of ammonium, which gives a white precipitate; six grains per gallon gives a turbidity only.

How do you detect Sulphuric Acid and Sulphates?

Chloride of barium and dilute hydrochloric acid give a white precipitate. One and a half grains per gallon give no precipitate till after standing. Three grains give an immediate haze.

How are Iron and Lead detected?

By means of sulphuretted hydrogen, giving a black precipitate or colour.

How are they distinguished?

Lead is only thrown down after the water has been acidulated, say with sulphuric acid; whereas iron is only thrown down in an "alkaline" solution.

So H_2S in an acid solution = lead.
H_2S in an alkaline solution = iron.

What are the Confirmatory Tests for Iron?

Red and yellow prussiates of potash; the red for the ferrous salts, and yellow for the ferric: in each case a blue colour or precipitate is produced.

How would you estimate the Amount of Lead or Iron present?

Lead.—Compare the colour produced by the natural water with that produced in an equal amount of distilled water containing a known amount of lead per gallon, when both are treated with sulphuretted hydrogen.

Iron.—Is estimated in the same way: compare the blue

colour produced in the natural water with that produced in pure water containing a known amount of iron. Keep the tubes in the dark for twelve hours or so, to prevent the blue precipitate from falling to the bottom.

How is the Saline or Ready-formed Ammonia estimated ?

A pint of the water (20 ounces) to be examined is introduced into a retort, connected with a Liebig's condenser ; into the water put 10 to 20 grains of pure recently calcined carbonate of soda, to make sure that the water is alkaline. The distillation is then commenced and carried on rapidly until about two or three ounces have passed over ; in this way any ready-formed ammonia is carried over by the steam and is condensed in the distillate, which is collected in a graduated tube and treated with Nessler's solution. If ammonia be present a yellowish or brownish colour will be produced the depth of which depends on the amount of ammonia present. The amount is estimated by comparing the colour produced in pure water containing a known amount of ammonia, with that produced in the natural water, both being treated with Nessler's solution.

How is the " Albuminoid Ammonia " estimated ?

When all the free ammonia has passed over, add to the water about an ounce of a strong alkaline solution of potassium permanganate, and again carry on the distillation, and the amount of ammonia estimated by Nessler's solution as already described ; the distillation is continued till the distillate is found practically free from ammonia.

How is the " Albuminoid Ammonia " expressed in the above Operation ?

In " terms of ammonia," as the hot alkaline permanganate transforms it into free or fully formed ammonia. It completes the oxidation of the organic matters as far as free ammonia : it is known as Wanklyn's method.

Can the Amount of Nitrogenous or Oxidisable Organic Matters be expressed in any other Way?

Yes, in terms of "oxygen required" to oxidise it.

How is this done?

By means of potassium permanganate, in the presence of sulphuric acid. A solution of a definite strength is made and added to the water to be examined till no more of the solution is decolorised, until the red tint is permanent for half-an-hour.

Does this distinguish the different Kinds of Organic Matter?

No; recent sewage, ferrous salts, nitrites, and sulphuretted hydrogen, all reduce and decolorise the permanganate solution by removing its oxygen.

Name the Two Ways, then, in which the Permanganate may be used?

1. In the presence of alkalies: here we get the amount of organic matters in "terms of ammonia."
2. In the presence of sulphuric acid: in this case the amount is expressed in terms of the "oxygen required" to oxidise it.

If Ammonia alone be found in Water, what does it indicate?

It is nearly always present in small amount, probably from rain; if there be much, and no nitrous or nitric acids or chlorine, it probably comes from the decomposition of vegetable organic matters—*e.g.* in marsh water. If it exceeds ·08 parts per mille, it almost always comes from the fermentation of urea into ammonium carbonate = dilute urine, very recent. In this case, however, the water will be loaded with chlorides from the same source.

What is Nessler's Solution?

It consists of 108 grains of iodide of potassium dissolved in a small quantity of distilled water: an aqueous solution of mercuric chloride (corrosive sublimate) is added, until a slight

permanent precipitate is produced: now add 494 grains of caustic potash, and make up the solution to 7 ounces with pure distilled water. Mix, allow to settle, and draw off the supernatant fluid for use as required.

What is the Permanganate Solution?

It consists of 882 grains of caustic potash, together with 35·27 grains of potassium permanganate in 10 ounces of distilled water.

What Amount of Albuminoid Ammonia is sufficient to condemn a Water?

·00	per mille	= the purest.
·02 to ·05	,,	= very pure.
·10	,,	= suspicious.
·15	,,	= condemn.

What is Frankland and Armstrong's Method for estimating Nitrogen in Water?

1. For the nitrogen present in the form of ammonia and organic nitrogenous matter—first, destroy any nitrates or nitrites present by means of sulphurous acid, and then evaporate a given amount of the water to dryness: the total residue thus obtained is then heated with oxide of copper in a combustion tube, and the nitrogen and carbonic acid collected in a graduated tube. The CO_2 is absorbed by caustic potash, leaving the nitrogen.

2. For the nitrogen of the nitrites and nitrates, treat another part of the water with strong sulphuric acid, and collect the gases in a graduated tube near mercury; the nitrogen comes off in the form of nitric oxide: the volume of this is then halved for the amount of nitrogen.

What is Schultze's Modified Method for the Determination of Nitric and Nitrous Acids?

By this method both are converted into ammonia by the action of aluminium in an alkaline solution; the ammonia is

then distilled off, and the amount determined by Nessler's solution. The reagents required are a solution of caustic soda and sheet aluminium.

Name another Method for the same Purpose?

The same object is attained by the "copper-zinc couple"—a piece of pure zinc foil and a 3 per cent. solution of sulphate of copper. The action is allowed to go on till a distinct coating of copper is deposited on the zinc: the presence of oxalic acid hastens the process. Afterwards distil off the ammonia, and Nesslerise.

How is the Hardness of Water ascertained?

By means of a solution of soap in proof spirit. It may be done in two ways:—

1. Either by making the soap solution of a definite strength by careful standardising, so that each measure (grain or cubic centimetre) is equal to a grain of soap-destroying salts per gallon.

2. Or by making a water of a definite known hardness, by means of pure distilled water and chloride of calcium, and then seeing how much soap solution is required to neutralise the hardness of a definite amount of the artificial water; then test the hardness of the natural water, and compare the results. Read thus:—If so many measures of the soap solution are required to neutralise the hardness of a definite amount of the artificial water containing a known amount of lime salts, what is the hardness of the natural water that uses up, say four times the amount of soap solution?

How is the Calcium Chloride Solution made?

By dissolving a known quantity of pure white marble in hydrochloric acid and evaporating to dryness, to get rid of the acid, and then dissolving the residue in pure distilled water.

How is the Soap Solution made?

Either by—

1. Dissolving a piece of soft potash soap of the B.P. in equal parts of alcohol and water, and then filtering; or

2. Rub up so much of the lead plaster of the B.P. with dry potassium carbonate, in the proportion of 150 to 40; lead carbonate and potassium oleate (soft soap) are formed; dissolve in rectified spirit, and filter.

How is the "Total Hardness" estimated?

A certain amount of the water under examination is introduced into a wide-mouthed bottle, just as it is, and well agitated to get rid of the carbonic acid, it being sucked out after each agitation. The soap solution is then added from the burette, with brisk agitation after each addition, until a lather is formed which remains for at least five minutes over the "whole surface" in an *unbroken* layer. The bottle is laid on its side. Let it lie for half-an-hour and agitate again, and add a few more drops of soap solution, if necessary; see that there is no break in the lather, even after half-an-hour's rest. Then read off the amount of soap used up, and this = the degrees of hardness; only deduct a little, as a certain amount of soap is required to give a lather even in the purest water. This will then be the "total hardness."

How do you estimate the "Permanent" and "Temporary" Hardness?

A known bulk of the water is boiled in a flask with a narrow neck for an hour, care being taken to keep up the water to its original bulk by the addition of distilled water; after the water has thus been deprived of its carbonic acid, the hardness is again estimated in the way just described; this result is then read as the "permanent hardness." The difference between this result and the one obtained by working with the natural water (total hardness) give the "temporary hardness"—that got rid of by boiling.

Table of Water Analysis

Determine—

1. The total residue (total dissolved solids).
   This consists of—
   - (*a*) Volatile residue.
   - (*b*) Saline or fix residue, consisting of—
     - (1) Chlorine.
     - (2) Earthy salts.
     - (3) Sulphuric acid.
     - (4) Sometimes iron and lead.
2. The products of organic matter—
   - (*a*) Ammonia (" saline " or " ready-formed ").
   - (*b*) Nitrous acid or nitrites.
   - (*c*) Nitric acid or nitrates.
3. The amount of oxidisable nitrogenous organic matter (" albuminoid ammonia ").
   - (*a*) In " terms of ammonia."
   - (*b*) In terms of " oxygen required " to oxidise.
4. Hardness—

   Total { (1) Temporary. (2) Permanent.

PUBLIC HEALTH

AIR AND VENTILATION

What is the Average Composition of the Atmosphere?

One hundred volumes of air contain—

Oxygen	20·6	volumes.
Nitrogen	77·9	,,
Carbonic Acid	0·04	,,
Watery Vapour	1·5	,,
Ammonia, Ozone, Nitric Acid, Marsh Gas, Sulphurous Acid, Sulphuretted Hydrogen	Traces.	

What are the Functions of the various Constituent Parts?

"Oxygen" is the supporter of animal life.
"Nitrogen" serves to dilute the oxygen.
"Carbonic acid" and "ammonia" nourish plants.
"Ozone" is the great aerial scavenger.

Does the Amount of Oxygen vary?

Slightly. It is about
20·96-·98 in pure mountain air.
20·90-·87 in towns.
And least of all in low marshy places.

What is the Amount of Watery Vapour ?

It varies from 1 to 12 grains per cubic foot.

Does the Amount of Carbonic Acid vary ?

A little : say from ·02 per cent. to ·05. There is more in sea air by day.

Give the Chief Constituents of "Pure" and "Very Pure" Air.

PURE AIR—

Oxygen	20·96 per cent.
Nitrogen	79·00 ,,
Carbonic Acid	00·04 ,,

VERY PURE AIR—*e.g.* at seashore and mountains.

Oxygen	20·99 per cent.
Nitrogen	78·98 ,,
Carbonic Acid	00·03 ,,

What is the Difference between the Weight and the Volume of the Chief Gases ?

	By Weight	By Measure.
Oxygen	77	79·19
Nitrogen	23	20·81

How does the Watery Vapour vary ?

It varies directly with the temperature : the lower the temperature, the less can it hold in suspension, and *vice versa*. Usually 50 to 75 per cent. are requisite for complete saturation.

By what Means are the Composition and the Purity of the Atmosphere maintained ?

1. By the law of the "diffusion of gases." Gases tend to diffuse till the pressure of any given gas is the same at every part of the globe.
2. Dilution by winds.
3. Oxidation by ozone, etc.

4. The fall of rain washes down the suspended matters and absorbs the gases.

5. The green colouring matter of plants (Chlorophyll) in the presence of sunlight and moisture decomposes carbonic acid, retaining the carbon, but giving off the oxygen. Plants also absorb and decompose ammonia, and nitrogenous matters.

What is taken as the Measure of Impurity of the Air ?

The amount of " carbonic acid " present.

How can the Presence of this Gas be detected ?

By means of passing the air through a solution of lime water ; the water soon becomes milky, from the formation of the insoluble carbonate thus—

$$CaC + CO_2 = CaO, CO_2.$$

If Excess of the Gas be passed into the Water, what is the Result ?

The water becomes quite clear again.

How is this ?

On account of the formation of the bicarbonate of calcium, which is a soluble compound. It is usually said that the " excess " of carbonic acid holds the lime salts in solution.

How could the Precipitate be reproduced ?

By boiling the solution when the " excess " of carbonic acid is driven off and the carbonate again precipitated.

What does this explain ?

The " temporary hardness " of water.

Is the Carbonic Acid the Real Impurity ?

No, it is nitrogenous organic matters that constitute the real impurity ; but the carbonic acid forms an easily tested measure of the presence and amount of these matters.

Name another and even better Test.

The nose of a person "just come in from the comparatively fresh and pure outside air," otherwise the sense is blunted and cannot be depended on. Hence it is that persons "living" in a foul atmosphere do not detect the disagreeable odour.

When does the Air become dangerous and disagreeable?

It becomes "very close and unpleasant" when the carbonic acid reaches or passes 0·15 per cent., causing headache and rapid deterioration of health.

What Gases pollute the Air from Cesspools and Sewers?

Carbonic acid, carbonic oxide, nitrogen, sulphuretted hydrogen, and ammonium sulphide. The oxygen is lessened and the carbonic acid increased. Sewer gases are often combustible.

Give an Example of this.

At Clapham, in 1829, twenty boys, out of twenty-two, were affected by the opening of a drain at the school, though the workmen escaped, probably because they had become used to it.

What Change does the Air undergo in Respiration?

1. It loses oxygen—about 4 or 5 per cent.
2. It is heated some 13 or 14 degrees, the amount varying with the external temperature.
3. It obtains moisture—on an average about 10 ounces in twenty-four hours.
4. It obtains carbonic acid. The air loses a little more oxygen than it gains carbonic acid. As all the oxygen does not pass to combine with carbon, 1 per cent. is apparently lost; hence, when an animal breathes in a confined space, the atmosphere is absolutely diminished.
5. It obtains various organic impurities, as ammonia salts, partially oxidised organic matters, etc.

How can these Organic Impurities be readily detected ?

If one expires through "water," the water very soon acquires a bad smell; or if one breathes through a weak "solution of permanganate of potash" the pink colour is destroyed; or through "sulphuric acid," when it darkens from the charring of the organic matters.

State—

(*a*) *The Amount of Oxygen inhaled per Hour.*
(*b*) *The Amount of Carbonic Acid exhaled.*

(*a*) 1346 cubic inches of carbonic acid are exhaled per hour, or about 636 grains, or ·6 cubic feet.

(*b*) 1584 cubic inches of oxygen are inhaled per hour, or about 542 grains.

In twenty-four hours about 26 ounces of oxygen are absorbed and about 8 ounces of carbon exhaled, or nearly 28 ounces of carbonic acid. 350 cubic feet of air pass through the lungs in twenty-four hours.

What Gases Escape from—

(*a*) *Alkali Works.*
(*b*) *Chemical Works.*
(*c*) *Brickfields.*

(*a*) Hydrochloric acid gas, which destroys vegetation round about the work.

(*b*) Ammonia, ammonium sulphide, and sulphuretted hydrogen.

(*c*) The air from brickfields is usually very pungent, and contains much carbonic oxide.

What Substance is often found in the Air of Printing Offices ?

It contains antimony from the type metal—lead, 2 parts; tin, 1 part; and antimony, 1 part.

Compare the Carbonic Acid in Pure Air and in Expired Air.

In pure air, carbonic acid ·04 per cent.
In expired air . . 4·70 ,,

or

Carbonic acid in 10,000 of pure air = 3 parts.
Carbonic acid in 10,000 of expired air = 470 ,,

NOTE.—2000 persons will give off in two hours, 17 gallons of water, and as much carbon as could be got from a hundredweight of coals.

What are the Natural Sources of Ozone?

By oxidation of metals, decomposition of rocks, germination of seeds, growth of plants, falling of dew, rain, hail, and snow, collision between air currents, passage of lightning flashes, evaporation from saline fluids—*e.g.* the sea. All these simultaneously develop electricity and ozone. There is more ozone at high than at low levels.

What are the Characteristics of "Ground Air"?

It is rich in carbonic acid, and very often is associated with effluvia and organic gases, sometimes even sulphuretted hydrogen; clay soils especially give off much carbonic acid. Gases from sewers may also escape into the soil, and these cause a great increase in the amount of carbonic acid given off from the surface.

Name an Example where this is especially bad and dangerous.

In houses built over newly "made soils" the "ground air" is specially bad and dangerous for some time (three years at least), as the impure air from the miscellaneous collection of rubbish on which the house stands is "drawn up" by the warmth of the house—*i.e.* the warmth of the house acts as an aspirator.

What is the Weight of a Cubic Foot of Air ?

1 cubic foot weighs 536·6 grains; 100 cubic inches weighs about 31 grains.

What are the Sources of Impurity in the Air ?

1. Respiration of all living things.
2. Products of combustion in lighting and firing.
3. Solid particles and gases from trades.
4. Decay and putrefaction of vegetable and animal matters.

How much Carbonic Oxide is required to produce Death ?

1 per cent. will cause rapid death, ·5 per cent. is poisonous, and ·1 per cent. is injurious.

What is Water Gas ?

It consists of nearly equal parts of carbonic oxide and hydrogen.

Why is it so dangerous ?

Partly from its composition, but chiefly because it has no smell, and cannot therefore be detected.

How might this be prevented ?

By adding some vapour to it which has a marked odour.

How much Ozone will cause Death ?

When it reaches $\frac{1}{2\,4\,0}$ part of the atmosphere.

What is the chief Source of Sulphurous and Sulphuric Acid in the Air of Towns ?

From the combustion of coals. For every 1000 tons of coal consumed, 15 tons of sulphur are sent into the air in the form of sulphurous acid, and this is oxidised into sulphuric acid.

What takes place when Coal Gas is burned?

Carbonic acid, carbon monoxide, water, ammonia, and sulphur compounds are produced. One cubic foot destroys the oxygen from eight cubic feet of air, and produces two cubic feet of carbonic acid, and two and a half grains of sulphuric acid. It also raises the temperature of 31·29 cubic feet of air 100° F.

If the combustion is "imperfect," then

67 per cent. of nitrogen is produced,
16 ,, water, and
5 to 6 ,, carbonic oxide.
Also sulphurous acid and ammonia.

What specially favours the Production of CO?

When the gas is turned down low, so as just to leave a little blue bead burning.

Compared with a Man, how much Air does an ordinary Gas Burner vitiate?

A cubic foot of gas per hour destroys the atmosphere as much as one man, and an ordinary burner will consume about 3 cubic feet per hour; and each burner will therefore be equal to three men, unless the products are removed by a special channel. Hence the bad effects of gas-lighting.

How may this be lessened?

By the use of the electric light. This has lessened, in large factories, the percentage of absences from illness considerably.

How is the Amount of Watery Vapour in the Air estimated?

By means of the wet and dry bulb apparatus.

What is the Principle of this Method?

It consists of two thermometers, the bulb of one being covered with a piece of cambric, which is constantly kept moist (the

" wet " bulb)—the bulb of the other one is not so covered (the " dry " bulb). In dry air the amount of evaporation from the " wet " bulb is great and rapid, and the temperature of that thermometer eonsequently falls; but in moist air the amount of evaporation is small, and therefore the fall of the temperature is also small: the amount of watery vapour can therefore be estimated by the differenee between the readings of the two thermometers.

Why does the Temperature fall when the Water evaporates?

Because, when water is transformed into vapour or steam, a large amount of heat is used up or rendered "latent," and in the present case this heat is extraeted from the mereury in the bulb eovered by the moist cambrie.

What should the Readings of the Bulbs in a House be?

Dry bulb should be from 63 to 65.
Wet bulb ,, 58 to 61.

The differenee should not be less than 4° or more than 8°.

What is the Limit of Saturation?

About 75 per eent. or less, or from 4·7 to 5 grains per eubic foot, but this, as already stated, depends on the temperature, thus—

At 50° F. it is saturated by 4·1 grains per eubie foot; while at 60° F. it will require 5·8 grains for eomplete saturation.

How does the Carbonic Acid in a Room differ from other Impurities?

It diffuses equally through all parts of the room, whereas the organie matters and watery vapour do not.

What Substances absorb the Organic Matters most?

They are absorbed most by wool, feathers, damp walls, and moist paper; least by straw and horse-hair.

Give the Smell Test for these Organic Matters.

It becomes perceptible when the carbonic acid reaches ·07 per cent., and becomes extremely close and unpleasant when it reaches ·15 per cent.

Dr de Chaumont gives the following degrees :—

At	·0568 per cent.	Not close.
,,	·0658 ,,	Not very close.
,,	·0804 ,,	Close.
,,	·0843 ,,	Not very foul.
,,	·0921 ,,	Pretty close.
,,	·0962 ,,	Very close.
,,	·1090 ,,	Extremely close.
,,	·1408 ,,	Extremely close and unpleasant.

Compare the Combustion of Dry Wood and Coal.

1 lb. of coal requires for its combustion 240 cubic feet of air, and gives off many sulphur compounds.

1 lb. of dried wood only requires 120 cubic feet of air, and gives off but very few sulphur compounds.

What is the great Difference between Complete and Incomplete Combustion of Coal Gas ?

In incomplete combustion much carbon monoxide is produced.

What is the Poisonous Constituent of Coal Gas ?

It is carbon monoxide, and when a person is killed by coal gas, it is really a case of carbon monoxide poisoning. Sulphuretted hydrogen, if present, is also poisonous ; but in great quantity this is an impurity and not a normal constituent of coal gas, whereas carbonic oxide is a normal constituent.

How much Carbonic Oxide is there in Coal Gas ?

About 4 to 5 per cent.

How much in the Fumes of Burning Charcoal?

10 per cent.

How much Coal Gas is required to cause an Explosion?

10 per cent. in the air of a room will cause an explosion when a light is introduced.

What are the Luminous Elements in Coal Gas?

Chiefly olefiant gas, and other hydro-carbons, having an analogous composition—*i.e.* having double the number of hydrogen atoms to the number of carbon atoms present.

What are the Non-Luminous Gases?

Hydrogen, carbon-monoxide, and marsh gas.

What are the Impurities of Coal Gas?

Carbonic acid, sulphuretted hydrogen, and carbon disulphide.

What amount of Sulphur is allowable in Coal Gas?

The maximum quantity allowed is 20 grains of sulphur per 100 cubic feet of gas.

How are the Sulphur Compounds detected?

By means of paper soaked with a solution of acetate of lead. When a jet of the gas is directed against this, if sulphuretted hydrogen be present, the paper will be blackened.

What is the Objection to Sulphur Compounds in Coal Gas?

In burning, it is given off as surphurous acid, which is very easily oxidised into sulphuric acid, and this spoils pictures, hangings, furniture, etc.

How is it that the Atmosphere of Towns is so black and foul?

Because the suspended carbon and tarry matters of the smoke do not rise higher than 600 feet, and therefore accumulate in the lower strata of the atmosphere.

Should the Products of the Combustion of Coal Gas be allowed to escape into Rooms?

No; they should be at once conducted to the outside by proper ventilators over each burner. The retention of the products cause great heat and humidity of the air of rooms.

Which pollute the Air most—Coal Gas, Oil Lamps, or Candles?

Coal gas gives off more carbonic acid than oil for an equal amount of light, but less than petroleum. Candles pollute the air more than gas—for an "equal illuminating power"—but gas gives off more watery vapour, and heats the air more, though it does not produce more carbonic acid.

How can Carbon Monoxide be detected in Coal Gas?

By means of a solution of cuprous chloride. This solution becomes coloured black from the presence of carbon monoxide.

How does Carbon Monoxide poison?

It is a light, very diffusible gas, and enters the blood very easily through the lungs, and combines with the hæmoglobin of the red blood corpuscles. It displaces the oxygen, and prevents the corpuscles from carrying any more.

What is the Peculiarity of the Blood in Cases of Poisoning by this Gas?

All the blood is of a "bright red" colour, both in the arterial and the venous parts of the circulation, and the spectroscopic appearances resemble those of arterial blood very closely.

How does Carbonic Acid cause Death?

Mechanically. It is a very heavy gas, and diffuses very slowly; hence it fills up the air vesicles, to the exclusion of oxygen. In poisoning by carbonic acid gas the blood is of a very dark venous colour.

What Diseases are Produced by Suspended Solid Matters in the Air?

Respiratory affections, such as catarrhs, with or without expectoration, bronchitis, emphysema, pneumonia, and phthisis.

Give Examples of these.

Phthisis in stonemasons, millers, and miners.

"Potters' asthma," a form of emphysema, due to the fine dust inhaled in this trade; so also in china-scourers. In both cases the dust is in an extremely fine state of division.

The steel-grinders are probably worst of all, as regards lung affections. Pearl button-makers are also bad, and suffer from bronchitis and hæmoptysis; also pin-pointers, and electro-plate workers.

Cotton, flax, and shoddy factories are bad from the dust, and workers suffer from bronchial affections.

Glass-makers, makers of grinding-stones, sand-paper, and Portland cement, all suffer from dust.

Match-makers, from phosphorus poisoning and necrosis of the lower jaw.

Makers of bichromate of potash suffer from ulceration and destruction of the mucous membrane and cartilages of the nose; also from ulcers and fistulous sores on the skin.

Brassfounders suffer from a form of ague, due either to the fumes of zinc or copper—the metals forming brass.

Painters and plumbers, from lead poisoning.

Silverers of mirrors and water-gilders suffer from mercurial tremors.

Workers in arsenic, as makers of wall-papers and artificial flowers, and copper-smelters, suffer from arsenical poisoning.

How can these Bad Effects be, to a Certain Extent, prevented?

By proper ventilation, as in mines. In steel-grinding, use the "wet" grinding if possible; have the wheel-boxes well

ventilated, and use respirators, either a simple cloth, or a magnet. In very dusty factories, provide shafts, and ventilate by extraction. In match-making, use the amorphous form of phosphorus, and have plenty of the vapour of turpentine near the workers. For painters, clean the hands carefully before eating, and use fluids to drink containing sulphuric acid.

What are the Signs of "Brassfounders' Ague"?

Lightness and oppression of the chest, nervous depression, shivering, fever, an indistinct hot or a profuse sweating stage.

What are the Signs of Chronic Arsenical Poisoning?

Smarting of the gums, the eyes become inflamed and watery, the eyelids œdematous, eczematous eruptions on the skin, and a silvery fur on the tongue. It may also pass on to paralysis, more or less general.

What Influence does Air exert as a Carrier of Infection?

Diversity of opinion prevails, though it is generally held that pathogenic organisms, by adhering to particles of dust, may be blown about by winds. Food-stuffs may accordingly be infected. Inhalation of the bacilli of tuberculosis may occur, and observation has proved that the meningo-coccus has been diffused among miners by the fine particles of coal dust. In another way it has been urged that the virus of smallpox may be aerially spread. This latter view is subject to question.

What Influence on Health does Fog exert?

The sickness and mortality rates from lung affections are greatly increased, but as soon as the air clears improvement at once manifests itself. During heavy fogs in London the mortality rate from respiratory diseases is almost doubled. The influence of the finely divided particles of dust, which form the basis of fog, and the acids which accompany them,

soon establish bronchitic and other pulmonary affections. It has been observed that during fogs the amount of carbonic acid increases.

What is understood by Saturated Air ?

When a volume of air at a given temperature can hold a definite amount of moisture, and no more, the air is said to be saturated.

What is Absolute Humidity ?

It is the amount of moisture which a volume of air contains.

What is its Saturation Deficiency ?

It is the difference between its absolute humidity and the amount which it is possible for it to hold.

What is its Relative Humidity ?

It is the ratio which its absolute humidity bears to its possible content.

What is Ozone ?

It is an allotropic modification of oxygen ; it is sometimes called condensed oxygen, as three volumes of oxygen condense to form two volumes of ozone : it has a peculiar odour, and has very powerful bleaching and disinfecting properties. It corrodes india-rubber, and is completely soluble in oil of turpentine.

How can it be prepared artificially ?

1. By passing a series of electric sparks through air or oxygen ; hence it is produced during the working of an electrical machine.
2. By allowing a stick of phosphorus to oxidise slowly in moist air.
3. By heating a platinum wire by a Bunsen.

4. By heating three parts of strong sulphuric acid with two parts of permanganate of potash; it will also be evolved slowly without the aid of heat.

How is its Presence detected?

By means of paper impregnated with starch and iodide of potassium. The paper becomes blue in the presence of ozone, as the iodine is set free, and makes the starch become blue.

How can the Amount be estimated?

It can be roughly estimated by exposing a strip of prepared paper for a given time, and then judging of the amount by the depth of colour produced. In this way a scale of colour tests may be formed.

How can Chlorine be produced?

1. From bleaching-powder by adding water, the carbonic acid of the air being sufficient to slowly displace the chlorine. It is not, however, strictly speaking, "chlorine" that is given off in this way, but "hypochlorous acid"; the effect, however, is the same.
2. From four parts of hydrochloric acid, and one part of the black oxide of manganese ("pyrolusite").
3. From four parts of common salt, two parts of sulphuric acid, and one of the black oxide of manganese, with a little water.
4. By mixing a solution of permanganate of potassium with hydrochloric acid.

How does Chlorine act?

It only acts in "the presence of water or moisture," but when this is present it is a true oxidiser, the chlorine taking the hydrogen and forming hydrochloric acid, while the oxygen of the water, in the nascent state, can then oxidise oxidisable

matters. In this way it decomposes sulphuretted hydrogen, forming water and sulphuric acid, and also in a similar manner decomposes ammonium sulphide.

What is Euchlorine?

It appears to be a compound of anhydrous chloric and chlorous acids, mixed with free chlorine.

How is it produced?

By the action of strong hydrochloric acid upon chlorate of potash; place the two substances in a saucer, containing warm water, and the gas is slowly evolved.

How does it act?

Just like chlorine, but is less irritating to the lungs, and the odour is more pleasant, so that it can be tolerated readily enough in a sick-room.

What Precautions are necessary?

It is a heavy gas, and therefore must not be placed on the floor, but on a shelf high up, so that it will fall slowly down: of course, being an explosive gas, it must not be produced in too large a quantity.

Can Iodine be used?

Yes; just expose the scales in a perforated box to the air, or heat them gently: it acts like chlorine, but is not so diffusible, and condenses easily.

Is Bromine used?

It might be, but it is far too irritating to the lungs, not to speak of its very bad smell. All that is necessary is to expose the fluid in a saucer.

How is Nitrous Acid produced?

From copper and nitric acid. The first result is nitric oxide, but this very readily takes up oxygen from the air, and forms nitrous acid. It is a very powerful oxidiser of organic matters, and, like chlorine, "transfers" the oxygen of the air to the organic matters in the nascent condition. It removes bad smells sooner than anything else. It is very irritating to the lungs, however, and must therefore be evolved slowly.

How is Sulphurous Acid produced?

1. The easiest way is to burn sulphur in the air.
2. By the action of sulphuric acid on certain metals as lead and copper.
3. By the reducing action of carbon, or substances containing it, as wood, upon sulphuric acid.

How does it act?

It only acts in the presence of moisture or water, and then in a way the very reverse of chlorine, as the sulphurous acid takes the oxygen of the water, and gives up the hydrogen in the nascent condition. It is not therefore a true oxidiser, though it decomposes sulphides, as sulphuretted hydrogen, forming water and free sulphur.

How does it extinguish a Chimney on fire?

In the same way: the sulphur is burned to form sulphurous acid; this in the presence of moisture—say from a wet sheet in front of the fire—removes the oxygen and sets the hydrogen free; but hydrogen is not a supporter of combustion, and so the fire is extinguished for want of oxygen.

What is the Popular Chimney Extinguisher?

Common salt thrown on the fire.

Is this good?

No; the very reverse, as the fire is fed, not extinguished, since the chlorine set free takes up hydrogen and gives off the oxygen, and so the fire is increased though "the smoke is lessened," and this is probably the reason of the popular belief in common salt as a fire extinguisher.

What Points have to be attended to to effect Ventilation?

1. The amount of air required.
2. The original cubic space.
3. The direction of the ventilating currents.
4. The rate of movement of the currents, as there ought to be no perceptible draught, even to the most sensitive.

In what Special Ways is the Air vitiated?

1. By increase of "temperature"; up to 5° F. or so above the general temperature, it feels fresh and comfortable; but when it reaches 12° or 13° F. above this, it feels very close.
2. By increase of "moisture." When the moisture is three-tenths only, all is well, but when it reaches 1 or $1\frac{1}{2}$ it is unpleasant. A very fair and healthy amount of moisture and heat is shown when the dry bulb stands at 60° F., and the moist bulb at 4° less—*i.e.* 55° F.
3. By increase of organic matters and carbonic acid.

How are the Evil Effects obviated?

1. By diminishing overcrowding.
2. Supplying plenty of fresh air.

What are the Regulations as to Cubic Air Space?

In permanent barracks . .	600	cubic feet per head.
In wooden huts . . .	400	,, ,,
In hospitals at home . .	1200	,, ,,
In hospitals in the tropics .	1500	,, ,,
In wooden hospitals at home	600	,, ,,

Enumerate other Cubic Capacities.

Cubic Capacities (minimum space per head in cubic feet).

Non-textile workrooms . . .	250
,, ,, (overtime)	400
Underground bakehouses . . .	500
Above ground where other artificial light than electric light is used . .	400 between 9 P.M. and 6 A.M.
Public elementary schools . . .	80 min.; floor space 8 sq. ft.
L.C.C. Schools	130 min.; floor space 10 sq. ft.
Canal boats (over 12 years of age) .	60
(under ,,) .	40
After cabin in canal boats not less than .	180
Fore cabin	80
Seamen's cabins	72
Cows in town cowsheds . . .	800
,, country ,, . . .	600
Horses	1500-2000
Common lodging house . . .	300
Rooms occupied by day and by night .	400
Infectious diseases hospitals . .	2000
Smallpox and typhus wards . .	3000
General hospitals	1200

Is mere Cubic Space enough?

Cubic space "alone" is not enough. The chief aim is to secure proper renewal of the air.

What is the Limit of Maximum Impurity in the Air of a Room?

It is ·06 per cent. of carbonic acid.

What does this Amount include?

It includes the "initial" carbonic acid—viz. ·04 per cent., that exists in pure air naturally, and the "respiratory" carbonic acid—viz. ·12 ·02 per cent. ?

How much Air per Head per Hour is required to keep up this Purity?

It requires 3000 cubic feet of air per head every hour to keep up this standard.

How does this Affect the Space required?

The space ought to be such that this amount of air can be passed through it for every person in the room every hour, without perceptible draught, as a draughty room is not a properly ventilated one.

How often may the Air in a Room be changed per Hour?

It may be changed three or four times an hour, but that is all that can be borne in this country unless the air be artificially warmed; hence, of course, the smaller the amount of space the oftener must the air be changed in order to secure 3000 cubic feet per head per hour.

Note, then, these Three Points.

1. The limit of maximum impurity is ·06 per cent. of carbonic acid.
2. That we require 3000 cubic feet of air per head per hour to keep up this standard of purity.
3. That we should, if possible, allow 1000 cubic feet of space per head, as this will only necessitate three complete changes of air per hour. If the space be 750, the air must be changed four times per hour, as $4 \times 750 = 3000$. In estimating cubic space allow 3 cubic feet for each person and 10 cubic feet for each bed.

How would you calculate the required Amount of Air?

Let

e = the quantity of carbonic acid exhaled by an adult per hour—viz. ·6 cubic feet.

r = the ratio per cent. to which it is desired to reduce the vitiation—viz. ·06 per cent.

R = the carbonic acid naturally existing in the air—viz. ·04 per cent.

Then $\frac{e}{r-R}$ the required dilution of air per hour in cubic feet.

Reduce all the terms to cubic feet,

and r = ·0006 and R = ·0004, and so

$$\frac{\cdot 6}{\cdot 0006 - \cdot 0004} \quad \frac{= \cdot 6}{\cdot 0002} = \frac{2}{6000} = 3000$$ cubic feet per head per hour.

How fast must the Air move to cause a Draught?

Air at a temperature of 55° to 60° F., moving at the rate of $1\frac{1}{2}$ feet per second, does not cause a draught.

At 2 or $2\frac{1}{2}$ feet per second some people will feel a draught.

At 3 or $3\frac{1}{2}$ feet per second all can feel the draught.

If the air be warm it may move faster without causing a draught.

What follows from this?

That we must aim at having that amount of cubic space, and an area of inlet for fresh air, that the currents will not need to travel faster than $1\frac{1}{2}$ feet per second.

What Space is allowed for Women and Children?

The same as for adult males—3000 cubic feet—unless in the case of children under five years of age. As a rule a child should get as much space as an adult.

What are the Different Forms of Ventilation?

1. Natural Ventilation—*i.e.* by forces which are continually acting in nature, as diffusion, winds, and differences in temperature.

2. Artificial Ventilation—*i.e.* by mechanical forces. The air—

(*a*) May be drawn out = the "vacuum method," or
(*b*) May be forced in = the "plenum method."

What are the Means of Natural Ventilation?

1. By diffusion of "gases."
2. By winds.
3. By differences in weight and volume of masses of air of unequal temperature.

How does Diffusion act?

Gases diffuse into space or through porous substances at a rate inversely proportional to the square root of their density, and therefore the lighter the gas the faster it diffuses.

Is the Effect of Diffusion, as a Ventilating Agent, very marked?

Not very, but still appreciable; thus, the diffusion through—

A square yard of sandstone is 5·7 cubic feet per hour.
A square yard of limestone, 6·5 cubic feet.
A square yard of brick, 7·9 cubic feet.
A square yard of mud, 14·0 cubic feet.

How does the Wind act?

1. By direct action, blowing through and through ("perflation"), as in cross ventilation of large rooms, and hospitals with windows on both sides of the ward.
2. By diffusion through the walls of houses.
3. By its aspirating power, as blowing over a chimney; the moving air causes a partial vacuum or rarefaction in its path, and then the air naturally is forced from the place of greater pressure to that where it is less; the wind therefore causes a current at right angles to itself up the chimney.

Why is Wind alone unreliable as a Ventilating Agent?

Because its movement is very uncertain and it is difficult to regulate.

What do you mean by "Still" Air?

Air is often called still when it is moving at the rate of 1 or $1\frac{1}{2}$ miles an hour.

Explain how Wind may impede Ventilation?

Because air in motion ("wind") has weight, and it thus may impede the exit of air from a tube, as it may actually blow down the tube, according to the direction and angle of inclination of the wind current.

What are the Different Ways of using the Window in Ventilation (Perflation)?

1. The windows may simply be opened. When this plan is adopted they should be opened both at top and bottom to obviate the unpleasantness arising from draughts. By this plan the cold air is apt to pour in like a cascade and in place of mixing equally with the air of the room may make for the nearest outlet.

2. The top of the window, or a part of it, may be made to slope inwards when opened; this plan directs the current of cold air up towards the ceiling, so that it will be warmed before it descends to mix more equally all through the room.

3. May have a glass louvre in the top centre pane.

4. May use double panes, the outer one open at its lower border, and the inner one open at its upper border; here again, the current coming in will be directed upwards towards the roof; the double panes, too, lessen to a great extent the loss of heat through the glass.

5. Potts' plan was to make use of panes of perforated glass.

6. Dr Bird's plan is to raise the lower sash, insert a piece of board so as to completely close up the opening thus made; in this way the fresh air comes in at the middle between the sashes and is directed upwards towards the ceiling.

7. Another plan is to fit a wire screen at the top so that it unfolds when the window is pulled down, and folds up when it

is shut; this ensures minute sub-division of the incoming current, the difficulty is that the meshes are apt to be clogged.

Why are Double Windows warmer than Single?

Because between the two windows there is a layer of still warm air, the glass of the inner window being much warmer than the air outside.

What happens with Single Windows?

During cold weather the glass is as cold as the air outside, and when the warm air in the room impinges upon it, the air is cooled down and rendered heavier, and so falls down upon the persons in the room. This alone is sufficient to cause an uncomfortable "draught."

How is the Wind used to Ventilate Ships?

Either by means of a canvas tube held open by hoops and fixed to face the wind (wind sails) or by tubes fitted with cowls turning to the wind; in this way the wind is forced down between decks and into the recesses of the vessels.

What is Potts' Plan?

It consists of a perforated hollow metal cornice running round the whole room, and divided longitudinally throughout its whole length into two separate channels by a plate attached to the lower one; the fresh air is admitted through openings in the wall into the lower channel, and falls imperceptibly into the room through the numerous perforations. The upper channel communicates either with the smoke flue or with a ventilating shaft, and the foul air passes into it through the numerous perforations.

Is this a Good Plan?

Yes; Mr Robson, architect to the London School Board, spoke very highly of it. The cold air too readily descends

from the lower channel, while the foul air being lighter rises to the roof, and easily enters the upper channel.

What is Mr Varley's Plan?

It consists of a perforated zinc tube, communicating with the external air, passing along the cornice of three sides of the room, while on the fourth side is another perforated tube, connected with the chimney.

What is M'Kinnell's Plan?

It consists of one tube within another, the open areas of which are equal. The inner tube is the outlet, because the outer one keeps it hotter and causes an up-current; it is also the higher of the two, and should be fitted with a cowl turning from the wind. The air entering the outer one is thrown up like a spray towards the ceiling by means of a flange. Both tubes should be situated in the centre of the ceiling or roof. If there is a fire in the room, both may become inlets; and if the doors or windows are open, both may become outlets.

What is this Method best adapted for?

It can only be used in upper rooms or one-storeyed buildings. It is best fitted for square or round rooms, or small churches. It is not so good for long rooms.

How do Unequal Weights of Air act?

If the air in a room be heated or made moister, it expands and endeavours to escape, because, bulk for bulk, it is lighter than the external air, and it therefore passes out, or rather is forced out, and the cold air passes in, to be in turn heated and again be pressed out. The air expands one part in 491 from 1° F.

What is the Pressure of the Atmosphere?

It is 14 lb. on the square inch—*i.e.* it is the weight of a column of air, an inch square, and five miles in height.

With what Force would this rush into a Vacuum?

At a velocity of 1339 feet per second, as the velocity in feet per second of falling bodies is almost equal to eight times the square root of the height through which they have fallen. In this case the height is five miles.

But a Room is not a Vacuum, how fast will Air rush into it?

In this case the velocity will be due to a height that represents the difference of pressure outside and inside.

What is the Rule?

The height from the aperture at which air enters to that from which it escapes, multiplied by the difference of temperature between the outside and inside, and divided by 491; this will give the difference in pressure outside and inside.

Let the height be 20 feet, and the difference of temperature 15° F., then—

$$\frac{20 \times 15}{491} = 0{\cdot}61 \text{ of a foot,}$$

and eight times the square root of this 6·248 feet per second, per square inch, as the velocity of the inflowing current.

Will this be the Real Velocity?

No; because a fourth, or a third, and in some cases a half must be allowed for friction. The lessening due to friction is in proportion to the length of the tube. Angles greatly increase the friction.

What Total Size of Inlets and Outlets should be allowed?

About 24 square inches per head for inlet, and the same for outlet; but it is necessary to have some means of lessening or closing these inlets in very cold weather or in high winds.

Where should the Inlets be placed?

They should be so placed as to be fed with fresh air from a pure source; they should be short, direct, and easily got at to be cleaned; they should be small and many, rather than few and large—48 to 60 square inches should be the maximum size. The end towards the room should be trumpet-shaped, or expanded so as to mix the air; and if placed above the heads of the people, the current should be directed upwards towards the ceiling, and be finely divided. The outer end must be protected from wind and rain and have some means of partly closing it. Wire gauze at the inner end will also help to subdivide the current. They must not be placed too near an outlet else the current will sweep right through; theoretically they should be placed low down, but, if so, the air would have to be heated; if the air is not heated it must be let in above the heads of the people, about 9 or 10 feet from the floor, and be directed upwards towards the ceiling. The air may be filtered through cotton wool or muslin or flannel, or it may be made to pass over trays of water.

Where should the Outlets be placed?

If artificial heat cannot be used to aid the extraction, they should be placed at the top of the room; if artificial heat is to be used they may be placed at any convenient point. Without artificial heat they are to be placed at the highest points, and the tubes should be as far as possible enclosed within walls, and not outside an external wall, so as to keep the air from being cooled and falling back into the room, or allowing the moisture to be condensed. They should be as straight as possible, without angles, and should be internally quite smooth. They may be round or square, and should have a cowl at the outer end turning from the wind to assist by aspiration, and prevent rain passing in, and lessen the chance of down draughts.

What are the Causes of Down Draughts?

1. The wind may blow in and force the air down.

2. Rain may get in and evaporate and cool the air so that it becomes heavier than the air in the room.

3. The tubes exposed to cold, as when they are placed on the outer side of an external wall : this again cools the air and renders it heavier.

4. There may be another outlet with greater discharge.

How may Artificial Heat be employed to assist Extraction ?

By a chimney and open fire ; surround the smoke flue with foul air shafts ; a gas jet may be used to warm the outlet. An ordinary chimney is enough for three or four persons.

What Plans are sometimes adopted for Inlets ?

Ellison's perforated bricks are used sometimes ; so are gratings, and the Sherringham valve. The Sherringham valve is one of the best ; it closes at will by a balanced weight, and slopes inwards and upwards when open. The outer end is guarded by a perforated brick or zinc grating ; the air passes through the perforations and is then directed upwards towards the ceiling.

What is Tobin's Plan for Inlets ?

It consists of vertical tubes carried for a certain distance—fully 6 feet—up the walls of the room, so as to obviate the discomfort from down draughts. The tubes may be closed as will, and they usually open at a little distance above the head of the people, and the current is directed obliquely upwards towards the ceiling. It is a very good plan for rooms or class-rooms with windows only on one side, but may be used for any large hall or church.

Should the Exit Tubes be all one Height ?

Where there are several ventilating tubes used they must all be of the same vertical height, otherwise the highest will impede the action of the lowest.

Should the Inlets or Outlets be the larger ?

The openings for the admission of fresh air must be as large or even larger than those for the escape of foul, otherwise counter currents may set in and interfere with the exit and cause draughts, and cool the foul air and let it fall back into the room to be breathed over again.

Whether is Ventilation more difficult in Summer or Winter ?

It is much more difficult in summer than in winter, and therefore one must see that there are sufficient tubes for summer use.

What is the Best Form of Ventilation ?

That which is spontaneous, self-acting, always in place, cheap, easily provided, does not easily get out of order, and requires no care from the inmates.

What is the Main Artery of the House as regards Ventilation ?

The staircase ; from this the rooms are supplied and the fires fed, hence the staircase should be cut off from the basements and be provided with plenty of fresh air.

How should a Common Stair or Lobby be ventilated ?

1. By the door itself.
2. By the fan-light above the door, which should be kept open night and day in summer. In this way the various rooms would be ventilated and the fires fed. In winter the air in the lobby should be warmed.

Give Examples of Artificial Ventilation on the "Vacuum Method."

The air may be "drawn out" on the extraction principle by—

1. Heat—*e.g.* the common chimney.
2. Steam jets.
3. Fan or screw.

What is the Objection to the Common Chimney?

Much of the heat is carried up the chimney, and is said to be thus lost; probably seven-eighths pass off in this manner. It is not altogether lost, however, as this "lost" heat serves as a very efficient ventilating agent, though a good deal of fuel no doubt is wasted.

How does the Fire feed itself with Air?

The air rushes towards it from the doors and windows, and any other opening; but if the doors and windows are too tight the fire will feed itself by causing a current down the chimney, and this current enters the room in puffs carrying smoke with it, this being one cause of smoky chimneys. To cure this provide proper inlets.

What is the Course of the Air Currents feeding the Fire?

The air enters beneath the door, passes towards the fireplace, where it is heated—one part passing up the chimney with the smoke; while the other curls up in front of the fire, and back along the roof where it cools, falls down, and is again drawn towards the fireplace.

Is the Room thus equally warmed and ventilated?

No; as the air entering is cold, the end of the room opposite the fire is too cold, and the cold current along the floor chills the feet; besides the foul air is not carried away.

Is the Chimney a sufficient Ventilator?

Yes; it provides outlet enough for four or five persons.

Where should Fireplaces be placed?

They should be grouped in the centre of the house, because, if on an external wall, much of the heat will be lost by radiation.

How may the Waste of Fuel in an ordinary Grate be overcome ?

By using the stove or grate fashioned on the principle of that designed by Galton.

Give a short Description of this Grate.

It provides an air chamber at the back in which the air is heated before it enters the room. If it be built on an outside wall the air can pass directly into the air chamber, but if it be on an inner wall a special fresh air channel must be provided to feed the chamber. On the back of the stove projecting into this air chamber are large flanges which increase the heating surface. The smoke flue also passes through the chamber and helps to heat the air too ; the flue then becomes continuous with the chimney. The fresh heated air enters the room at a louvred opening, at a point between the fireplace and the ceiling, or by two such openings—one on each side of the chimney breast.

What are the Advantages of this " Grate " ?

1. It may be made to fit into existing fireplaces.
2. It has the same cheerful appearance as the ordinary grate.
3. It produces the same degree of warmth in the room as an ordinary grate, but with one-third the quantity of fuel.
4. The temperature of the room is more equable, and draughts are avoided.

Mention some of its Rivals.

1. Boyle's grates, where the heated air enters through openings along the top of the grate.
2. Shorland's Manchester grate, where the heated air enters through the shelf of the chimney-piece, or may be conveyed by special tubes to bedrooms above.

How can Ordinary Grates be improved ?

In order to economise fuel, the stream of cold air passing through the " bottom " of the grate should be cut off, either by

using solid fire-briek bottoms or by closing up the open chamber under the grate by a close-fitting shield or door, which any blaeksmith ean make; these shields are ealled "eeonomisers."

What are Mr Teale's Rules for Fireplaces?

1. Use as mueh fire-briek as possible in their eonstruction.
2. Make the baek and sides of fire-brick.
3. The baek should lean or areh over the fire.
4. The bottom of the fire or grating should be deeper from before baekwards—not less than 9 inehes for a small room.
5. The slits in the grating should be narrow.
6. The bars in front should be narrow.
7. The ehamber beneath the fire should be closed in front by a shield or economiser, or an iron plate may be used instead to fit the bottom of the grate and laid on the bars.

How could you assist the Ventilation of a Room by a Common Chimney?

By introducing a flue entering at the ceiling and running alongside the ehimney.

How could the Air in Large Houses be easily heated?

By having eoils of hot-water pipes, or stoves in the halls and staireases, the heated air ean then be admitted to the various rooms.

What are the Objections to Stoves?

They are apt to dry the air too much.

How can this be avoided to a Certain Extent?

By having a dish with water on the grate, or coat the iron with siliea.

How are Coal Mines ventilated?

Also on the extraction prineiple; a furnace is kept burning at the bottom of the "up-east shaft," and in this way a fresh

supply of air is drawn down the other shaft and made to traverse the various galleries by an arrangement of partitions and double doors which can be opened and closed at will.

How much Air is required in Mines ?

At least 2000 cubic feet per head per hour in well-ventilated mines, but in mines with much fire-damp it ought to be 6000 cubic feet.

If the Mine has only one Shaft, how is it managed ?

No mine ought to have only one shaft, but the single shaft could be divided into two by a partition, one half being " down-cast," the other " upcast."

What is " Fire-Damp " ?

It is a gas, known also as marsh-gas, as it is produced in marshes, by the decomposition of vegetable organic matters, as leaves, wood, etc., in marshes and stagnant pools ; and this also has been its source in the coal seams during the processes necessary for the formation of coal from vegetable matters of bygone ages. Chemically it is known as hydride of methyl, HCH_3 or CH_4. It has no smell, colour, or taste, and therefore the unaided senses alone cannot detect its presence in a mine.

How then can it be detected ?

By means of the " safety lamp " ; the gas passes inside the gauze to the flame, and burns round about the flame of the lamp with a bluish-yellow light—the " corpse light " of miners. When this is the case, then this part of the mine should be swept by the ventilating current, and the workmen should leave it altogether for a time.

What Volume of Air is required to effect a serious Explosion ?

Ten volumes of air to one volume of marsh-gas : this would form the most complete and destructive explosion.

What takes place when it explodes ?

Carbonic acid and water are formed, and the mine glows like a furnace from the ignition of the fine coal dust in the air of the mine.

What is the " After-Damp " ?

It is the carbonic acid, and it is as much to be dreaded as the " fire-damp," as it kills by asphyxia.

How is it that a Fall of the Barometer indicates Danger to a " Fiery " Mine ?

Because the fall of the barometer denotes a fall in the atmospheric pressure. Now, as long as the atmospheric pressure is greater than the pressure with which the fire-damp tends to escape from crevices in the coal seams, the fire-damp is imprisoned as it were, and only escapes by diffusion and from the ordinary " makings "; but when the atmospheric pressure falls below the pressure of the fire-damp, then it issues freely from the craeks, etc., in the coal seam ; and this is what takes place when the barometer falls below a certain point.

How is the Foul Air removed from Ships ?

By means of tubes from all parts of the ship, opening into the ash-pit beneath the eooking furnaces, and when the furnace doors are closed the foul air is then drawn from all parts of the ship to feed the fires. Another plan is to have an iron casing surrounding the bottom of the funnels and upper part of the boilers and steam pipes, leaving a spaee of three or four feet between the casing and the pipes, and when the fires are lighted there is a great draught, this arrangement acting as an extraction shaft, so that even the hold can be thus ventilated, and the temperature of the stoke-hole is reduced from 130° to 60° F.

How much will an Ordinary Gas Jet discharge?

One cubic foot of gas will produce heat enough to discharge 1000 cubic feet of air, and as an ordinary burner will burn 3 cubic feet per hour, the ordinary burner will thus discharge 3000 cubic feet; but unless the products of its own combustion are removed at once by proper tubes over the jet, it will vitiate 9000 cubic feet per hour.

Is the Fan much used?

The fan is used in mines, and has been made to extract as much as 45,000 cubic feet of air per minute. It is also used in mills where there is much dust, as in Manchester, and also in paper mills at some stages of the rag preparation.

What is the "Punkah"?

It is simply a gigantic fan, suspended above a table or bed, a line passing from it to the attendant outside, who pulls it and thus sets the air in motion. The punkah may also be moistened; this increases its effect very much, as the air is cooled by the evaporation of the water.

What is the Van Hecke System?

It is a method used in France and America for the ventilation of several large hospitals; the air is forced by a fan into a basement chamber, where it is heated before it enters the wards.

What is the Best Form of Ventilation?

On the whole, natural ventilation is the best; of the artificial forms, extraction is better than propulsion, as regards cost, efficiency, and stability.

What are the Advantages of Propulsion?

1. The certainty and ease with which the amount thrown in can be altered.

2. The air can be taken from any point, and can be washed, filtered, cooled, and heated, at pleasure.

What are its Disadvantages ?

1. The great cost.
2. The chances of the engine breaking down.
3. Difficulties in distributing the air properly.

What has to be specially provided for in Lighthouses ?

1. The large amount of water produced—20 pints per hour—which condenses and freezes on the glass and dims the light.
2. The large amount of carbonic acid produced, which affects the health of the keepers.

How is this carried out ?

It was remedied by Faraday, who caused a central chimney to be constructed through the roof of the lantern into the open air, the upper end of the tube being protected by some kind of covering ; then over the glass chimney of each lamp was placed one end of a small tube, and this tube was then curved up and opened into the central chimney. These tubes carried off the watery vapour and carbonic acid.

What are the Special Points about Inlets and Inlet Channels ?

1. The air should enter with a low velocity.
2. It should come in a little above the level of the heads of the people.
3. It should be directed upwards towards the ceiling.
4. It should be minutely sub-divided.

When the inlets are " near the floor " they give rise to cold, and are also apt to become choked up ; if " near the roof," they soon cease to exist as a distinct current. The inlets must be taken from a fresh source and about 2 feet from the ground the surface near being paved and sloped away from the wall so as to carry off the wet quickly. If it is heated artificially, it should be about 68° to 75° F.—the average indoor temperature being about 58° to 66° F. The air channels should be—

1. Short.
2. Direct.

3. Accessible, so as not to collect dirt, insects, etc., and thus pollute the air.

4. Filter, if necessary, through frames filled with cotton wool or sliced sponge.

5. The shafts passing to each room should be independent of each other, else foul air may pass from one into the other. There should be as few turns as possible, and if turns are necessary make the shaft higher. The circular form is the best, as it gives the greatest area for the least surface.

How do Underground Channels modify the Air?

The temperature of the air is raised in winter, and lowered in summer. These channels should be water and air tight, else the ground air and water will tend to pass in unless the pressure of the air inside be greater than that outside.

What are the Objections to Tobin's Tubes?

There is a good deal of friction; dust, insects, etc., are apt to collect, and by-and-by make the air impure; they do not readily act as outlets should necessity require.

How do you judge of the Sufficiency of Ventilation?

1. Measure the space for each person.

2. Investigate the movement of the air, its distribution, inlets, and outlets, and the amount supplied.

3. Examine the contained air by the senses.

4. Examine it chemically and microscopically, if necessary.

5. Estimate the temperature, moisture, organic matters, etc.

In measuring the Cubic Space, what Deductions have you to make?

Allow 3 cubic feet for each adult, and 10 cubic feet for a bed, and deduct these from the estimated amount.

How do you judge of the Direction of the Air Currents?

There are many ways—

1. Smoke from smouldering cotton.

2. Fibres of floss silk.
3. Small bits of feather or paper.
4. Ammonia, and hydrochloric acid gas.
5. Hydrogen balloons.

Is the Flame of a Candle trustworthy ?

Not when the currents are delicate. It requires a current of some force to deflect it. It is useful to show whether an opening is acting as an inlet or outlet.

How is the Rate of Movement determined ?

It may be judged of by :

1. An anemometer. This is like a small windmill, with wheels and index, like an ordinary gas meter. It is allowed to revolve for a known period, and then the number of cubic feet read off the index, as, of course, the faster it goes the greater is the number of cubic feet issuing in or out of any opening. It should be placed in the " centre " of the chimney or air shaft.

2. By a manometer. Judge by the pressure exerted on the surface, and how high the water is raised in the tube.

3. By calculation, by means of Montgolfier's formula.

4. By the deflection of a candle flame, a deflection of 30° is said to indicate a rate of one foot in one or two seconds.

What is the best Time to test the Efficiency of Ventilation ?

Some time between midnight and 5 A.M.

In judging by the Senses (Nose), what is necessary ?

It is necessary to remain for some time in the fresh open air before entering the room or ward, otherwise the sense of smell is apt to be blunted.

How is the Carbonic Acid estimated ?

By " Pettenkofer's method."—Pure clean lime or baryta water is used, and a glass vessel holding from half to one and

a half gallons. The jar is carefully cleaned and dried, and then filled with the air of the room by pumping it in with a bellows or bellows pump. Then 60 c.c. of clear line or baryta water are put in, and the mouth closed with an indiarubber cap, the vessel well shaken, and then left to stand for six or eight hours. The carbonic acid is absorbed, and to this extent lessens the " causticity " of the lime water ; as the causticity is known beforehand, the difference will give the amount of lime or baryta water that has united with the carbonic acid.

How is the " Causticity " Estimated ?

By means of a solution of oxalic acid of known strength. After the carbonic acid has all been absorbed 30 c.c. of the water is taken and neutralised with the oxalic acid, and this shows how much has been already neutralised by the carbonic acid.

How is the Neutralisation Point known ?

By means of turmeric paper ; go on till no brown stain is produced on paper.

Is any Correction necessary ?

Yes ; correct for temperature, if necessary. 62° F. is the standard temperature, and correction is necessary if the observation be made in a room below or above this point ; because, when the temperature is low, the air is condensed and more, therefore, will be examined ; and if high, the air is rarer and less is examined.

What other Plans are there for estimating the Carbonic Acid ?

1. May use caustic potash, and then weigh.
2. May judge roughly of the milkiness of lime water by the eye.
3. Angus Smith's method is easy, and may be applied by anyone. The chief point is that a ten and a half ounce bottle filled with the air of the room, and containing half-an-ounce

of lime or baryta water, should give no milkiness, provided the air is as pure as it should be—*i.e.* if it does not exceed ·06 per cent. in the air of the room.

How is the Nitrogenous Matter estimated?

In the way already described, by drawing the air through pure water, and then estimating the "ammonia" and the "albuminoid ammonia," as under water analysis; or draw the air through a solution of potassium permanganate of known strength, and then estimate the undecomposed permanganate by means of oxalic acid. This plan gives the organic matter in the terms of "oxygen required" to oxidise it.

How is the Watery Vapour estimated?

1. By means of the dry and wet bulb thermometer (see page 12), or

2. By means of the hair hygrometer. This is a human hair freed from fat by ether or a weak solution of caustic potash; one end is fixed, and the other is attached to a needle. It acts more quickly than the dry and wet bulb thermometer.

How are the Sulphides detected?

Sulphuretted hydrogen is best detected by means of blotting-paper dipped in a solution of acetate of lead.

Ammonium sulphide is detected by paper dipped in a solution of nitro-prusside of sodium.

How would you examine the Air microscopically?

Take a small bent glass tube, wash, dry, and heat it to redness, and when cool place it in a freezing mixture. An india-rubber tube being then fixed to one end, the air is drawn slowly through; the watery vapour of the air is thus condensed, and solid particles are carried down with it. A drop of this fluid is then examined with an immersion lens. In exact analysis of air, it is first caused to pass through tubes or bulbs containing caustic potash to remove the carbonic acid; then through

tubes filled with pumice stone soaked in strong sulphuric acid, to remove the watery vapour; and then through a long tube filled with bright copper heated to redness, to remove the oxygen; and what remains is then read as nitrogen. The air might also first be passed through cotton wool to filter it from suspended particles, and then through distilled water to remove any ammonia present.

What are the Causes of Smoky Chimneys?

1. From want of sufficient inlets from other places, and, therefore, air comes down the chimney to feed the fire.

2. The fireplace too wide and too high.

3. The chimney too high, and, therefore, the air cools and falls back again.

4. The chimney too short and too wide. To cure this contract the throat, and make all the air pass through the fire, as with the large flue the air is not all heated.

5. One flue entering another, and if both are not going at the same time, the smoke comes down.

6. Chimneys may overpower each other, if there are two in one room and the fires are not kept equal, or in different rooms communicating by a door; also, if all the doors and windows fit tightly, the kitchen fire may overpower all the others.

7. The top of the chimney may be commanded by larger buildings, or a hill, and the wind blowing over falls down like a waterfall on the top of the vent. To cure this, raise the chimney, or use a cowl.

8. Improper position of door, it being on the same side as the fire, and when the door is opened the air rushes past the fire and whisks out the smoke. To cure this, use a screen to protect and direct the current past the fire, or shift the door.

9. Room with no fire filled from another with a fire down the cold funnel. For this contract, or close the opening entirely.

10. Badly shaped and fanciful chimney pots, with many points and angles that only increase friction, and deflect the air *down* the chimney.

11. Cracked funnel, or a funnel placed in an outside wall.
12. Birds' nests, etc., blocking it up.

What are the Objections to open Fireplaces?

1. They waste much fuel, as seven-eighths of the heat passes up the vent.
2. Unequal heating at different parts of a room: radiant heat being only one-fourth as great at double the distance from its source.
3. Cold draughts from the doors and windows.
4. Cold feet; because the entering air is cold and lies along the floor of the room.
5. Bad ventilation.
6. Smoke and dust.
7. Danger to property from fire.
8. Danger to person from fire.
9. Expense of attendance.

Open fires will draw the air from all parts of the house to feed themselves, as from the basement, water-closets, sinks; unless these are in projecting buildings, and cut off by lobbies and double doors from the main part of the house, and are also ventilated from the open air. The staircase is the chief feeder of the fires and rooms, and, therefore, it should be cut off very carefully from all sources of pollution.

What are the Advantages of the Simple Dutch Stove?

Its simplicity, and it is chiefly used where fuel is scarce. The heating effect is from the whole surface, and from the surface of the flue as well. Can make use of almost the whole heat, without draughts, dust, or smoke.

What are its Disadvantages?

The air is spoilt—burnt, or has a sulphurous smell; it is also too dry, and has undergone certain electrical changes. It causes headaches, loss of appetite, and ophthalmia. The flue, also, may get red-hot and set fire to the house. A dish of water

near the stove helps to rectify the dryness. The metal of any stove should never be raised higher than 100° F., and never on any account be allowed to become red-hot, as then carbonic oxide may escape into the room—this gas having the power of passing through red-hot metal ; but it also may be formed by the contact of the carbonic acid of the air with the red-hot metal. The joints of stoves should be very well made, lest during contraction and expansion of cooling and warming, they become loose and let out smoke, carbonic acid, carbonic oxide, etc. An elbowed flue gives out more heat than a plain one.

Are Stoves Good Ventilators ?

No ; the air is apt to be stagnant. One pound of coal requires 150 cubic feet of air for combustion, or say 200 ; now, six pounds of coal per day would only require about 1200 cubic feet of air, and this is not enough to change the air once perfectly. Besides, the slow combustion is apt to produce much carbonic oxide, because the draught is small and it may escape into the room ; occasionally, also, marsh-gas is produced and may cause explosions.

How is Heating of Interiors affected ?

By radiation, conduction and convection.

Give Examples of Each ?

The radiant heat from an open fire passes through the air to the walls, furnishings and other objects in its path. The heat passes out in direct lines. The objects aforementioned absorb some of the heat and reflect the rest to other parts of the room. The furniture, walls, ceiling, etc., then diffuse the heat by *Conduction* and *Convection*. In this case of *Conduction* heat passes from one particle of matter to another in direct contact. It may be from one object to another which it touches, or from one particle to another of the same object. The best conductors are metals, copper being one of the best. Wood is a poor conductor, as also are woven materials and asbestos. By

Convection is meant the process by which heat is communicated to gases and liquids acting through their movement. Thus the heated portion expands and makes way for a cooler part, until the whole becomes warmed. Convection currents are accordingly established in every interior.

What Faults may be found with a Cast-Iron Stove?

In the first place the organic dust particles in its immediate vicinity may become charred and yield effluvia. Secondly, cast iron absorbs and transmits a considerable amount of carbon monoxide from burning coal.

What are the Advantages or Disadvantages of Gas and Oil Stoves?

Their advantages are that they are more prompt in results, more easily controlled, and therefore more quickly put out of action.

Their disadvantage is that the products of their combustion are discharged directly into the air of the room. Given proper ventilation, however, the effects need not be serious.

LIGHTING

What are the Agents employed for giving Artificial Light?

Gas, electric light, acetylene gas, petroleum and colza oils as well as candles.

What is the Composition of Inflammable Gases?

They are chiefly compounds of carbon and hydrogen. When these are sufficiently heated the hydrogen combines with oxygen to form watery vapour with the result that a flame without luminosity is produced. It is the particles of carbon which are rendered incandescent by the hydrogen flame. The combination with O forms CO_2 and traces of CO. The bright portion situated on the outside of the flame is the incandescent carbon, the inner portion, non-luminous, is the very hot hydrogen.

What are the Products of burnt Coal Gas?

The hydro-carbons are almost destroyed, the products being mainly nitrogen 67 per cent.; water 16 per cent.; carbonic acid 7 per cent.; with trace of carbon monoxide, sulphurous acid and ammonia.

What are the Disadvantages of Illumination by Gas?

The products of combustion are injurious to health, while the sulphurous acid from the sulphur compounds act injuriously upon furniture, books, and pictures. Air is heated and dried. If the proportions of gas and air be not regulated, unconsumed particles of carbon are given off to deposit as soot and to add further pollution.

Describe the Welsbach Incandescent Gas Burner.

It consists of a Bunsen with cap or mantle made of asbestos and rendered non-inflammable by treatment in the sulphate of zirconium. The mantle is suspended in the non-luminous portion of the flame but becomes incandescent, giving a brilliant white flame. The illuminating power is high and the heat less than that given off by ordinary fishtail or batswing burner. From a public health point of view, the Welsbach is the best type of burner to use.

What is meant by the Flashing Point of Oils?

Lamp oil is secured by distilling crude petroleum. During distillation a volatile spirit (benzoline) and other heavy oils are given off and separated from the lamp oil, or kerosene as it is now and again termed. Lamp oil contains various hydro-carbons and gives off an inflammable vapour which takes fire at certain temperatures. This temperature varies with different oils and is known as the "flashing point."

What is the Flashing Point and how was it regulated?

It used to be 73° F.; now it is 100° F. The former temperature was that defined by the Petroleum Act of 1879. Owing

however to the number of accidents occurring in connection with lamps a select committee appointed by Parliament increased the temperature to 100° F.

What Advantage has Electric Light ?

It does not consume oxygen ; it gives off very little heat, and the products of combustion are extremely slight.

CLIMATE

What Factors influence Climate ?

Distance from the equator, distance from the sea, altitude and prevailing winds.

What are the Conditions likely to exist in Mountain Climates ?

Great movements of air, lessened humidity, increased sunlight, freedom of air from impurities—mineral and organic, ozone is abundant, generally a low temperature. As a rule temperature decreases 1° F. for every 300 feet of altitude.

What Effect on Health has Residence at High Altitudes ?

Oxygenation of blood is increased because respirationis more active ; consequently the chest capacity and measurements are increased. The heart's action improves, and the digestion improves because tissue changes are encourage to take place.

What Disease has been selected for treatment at High Altitudes ?

Lung tuberculosis, but preferably only in the early stages of the disease. Those cases complicated by congestion are not so prone to improve, since the cold dry air is unfavourable to the condition. Spots sheltered from cold winds should be preferred.

What is the Character of the Climate of Mountains near the Sea ?

Liable to be excessively wet owing to the currents of air from the sea becoming chilled on encountering the mountains.

What is "Caisson Disease?"

The caisson is a large cylinder made of metal plates riveted together, and sunk into a stream. Into the interior of the caisson air is pumped at a sufficient pressure to expel any contained water. Subsequently workmen enter the caisson to carry on their work of excavation or erection as the case may be. Caisson disease is induced by the changes in atmospheric pressure to which the men are subjected.

What are the leading Symptoms of the Disease?

Severe pains in the ears, due to the driving inwards of the tympanum; deafness due to rupture of the tympanum; neuralgic pains; giddiness; loss of power in the legs, which may amount to paralysis; pains in limbs; epistaxis; hæmoptysis itching of skin and epigastric pain with nausea and vomiting.

What causes these Symptoms?

Three theories have been advanced; first, CO_2 poisoning; secondly, mechanical congestion of internal organs, and thirdly to increased solution by the blood of the gases in the compressed air, leading to the formation of gas emboli. The last theory is considered to be the most tenable.

How may the Condition be prevented?

Short shifts; when the pressure exceeds 35 lb four hourly shifts should be worked. When it is 50 lb every two hours. Abundant supplies of fresh air, electric lighting, decompression at the rate of one minute to every 3 lb pressure. Examination of all labourers and the rejection of alcoholics; instructions regarding self-inflation of tympanum.

What is the Climate of Small Islands and Sea-coast Towns?

Usually their climate is much more equable than that encountered inland. The variations between the day and night temperature are less marked, as also are the gradations between

summer and winter. The winds eoming from the sea are moist, pure, rich in ozone and free from organic or mineral impurities.

What are Isobars ?

They are lines eonneeting plaees showing equal barometrie pressures. These lines are drawn upon a weather map which will reveal the position and extent of eyelonie or anti-cyelonic systems.

What is a Cyclonic System ?

It has at its eentre the lowest barometrical pressure, and is surrounded by isobars of gradually inereasing pressure.

What are " Steep " and " Shallow " Gradients ?

The isobars will be near or far apart aeeording to the amount of depression in the centre. If the depression be great the isobars are elose together, in whieh ease the gradients will be " steep." If the depression in the eentre be shallow, the isobars will be further apart and the gradients " shallow."

What is an Anti-Cyclonic System ?

In this ease its eentre gives the highest barometrie reading, and is surrounded by isobars of gradually increasing pressure.

PUBLIC HEALTH

SEWAGE, AND ITS TREATMENT

What is the Best Method of Sewage Removal?

The water carriage system is best, for large towns at any rate, if there is plenty of water and good drainage.

What is meant by the "Separate" System?

Where there are two sets of sewers, one set for the fæces and urine, etc., and the other for storm water, rain water and subsoil water.

What are the Advantages of the Pipe Sewer System?

1. There is no percolation of sewage into the soil when the pipes are well jointed.
2. They can be quickly laid and require less excavation than brick sewers.
3. They can be made of various curves for different positions.
4. More easily kept clean.
5. Avoid great dilution of the sewage, and therefore lessen the expense of pumping, etc., in cases requiring special modes of treatment.

What is its Disadvantage?

It does not provide for the removal of the subsoil water, and in order to keep the soil in a good state a

special set of drains is required to dry it; the subsoil water can easily percolate into drain sewers.

What is the Objection to Brick or Drain Sewers?

If badly constructed they are leaky, as they may let sewage out and admit subsoil water. They may therefore be a source of danger to water mains, the soil and wells.

How are Sewers ventilated?

By means of manholes and upcast shafts. The former placed at intervals of 100 yards.

Is Charcoal an Unmixed Good?

No; it is apt rather to impede the ventilation.

NOTE.—The sewers should be absolutely watertight and not constructed to remove the subsoil water—though this feature, in Salisbury, was the means of reducing the deaths from phthisis to a very remarkable extent, by drying the subsoil; but the liquid sewage and gases are apt to pass out of the sewers and render the land "excrement sodden." In the case of seaboard towns this is specially bad, because the sewage is kept back in the pipes by the rising tide for many hours, and they thus become large cesspools. Still, if the soil be well drained and aerated, it has an almost immeasurable power of cleansing any liquid that may enter or pass through it, and thus render defective work harmless.

What is a "Drain"?

Properly speaking it is a branch sewer connecting houses with the main sewer.

What is a Sewer?

It is a conduit for the discharge of filth. Sewers may be 9 inches in diameter, or as many feet in diameter.

What is a "Drain-Sewer"?

Where the sewer and drain are laid side by side in the same trench, as in the "separate system."

What is Sewage?

Sewage is any refuse from human habitations that may injuriously affect the public health, and consists of—

1. Liquid refuse removed by water.
2. Solid garbage and contents of ashpit, privy, etc., removed by scavenger.

Should Liquid Sewage be allowed to flow into Rivers?

No; it must not flow into rivers even from isolated dwellings in country places, or even into canals, ponds or lakes, until it has been purified from all foul and noxious matters by the best practical and available means. This is provided for by the Rivers Pollution Prevention Acts.

What Amount of Impurity is allowable to flow into Rivers?

Not more than, in parts per 100,000, of—

Organic nitrogen	0·3	Dissolved matters.
Organic carbon	2·0	
Metallic arsenic	0·05	
Mineral .	3·00	Suspended matters.
Organic .	1·0	

What is a Good Plan for Isolated Dwellings?

To apply the sewage direct to the land itself, avoiding clay soils, and under-drain well. The sewage of 3000 or

more persons may be purified by "intermittent downward filtration," by 1 acre, under-drained 6 feet deep. But the land should have rest for two years; so use 3 acres instead of 1—*i.e.* 1 acre for every 1100 persons. This plan is specially good for isolated dwellings and institutions, and will yield some return in vegetables, crops of grass, etc. If "broad irrigation" be used, then take an acre for every 100 persons. Whatever plan be adopted it is better to make it at some little distance—say a quarter of a mile from the dwellings—so as to avoid the creation of nuisance. The surface of the land should be ridged and furrowed, and into these the sewage flows; while cabbages, etc., are grown on the ridges.

What is Sub-Irrigation?

Distribution of the sewage to the land *below* the surface by pipes.

Is it a Good Plan?

Not very; the pipes are apt to be choked up, and the land becomes "excrement sodden," which cannot be detected for some time after the evil has been established.

How are the Pipes laid?

The pipes used are 2-inch agricultural drainpipes placed 10 to 12 inches below the surface on a bed of larger pipes divided into two equal parts; the sewage flows out at the joints. The evaporation and cold produced by this method is bad for vegetables and human beings alike.

How should the Private Communicating Sewers ("Drains") be made?

The private sewer connecting the houses with the main sewer should consist of stoneware glazed pipes, firmly

jointed so as to be water and air tight. Puddled clay is no good as jointing to keep out roots of trees. It dries and cracks: gaskin and cement make the best joints. Escape of sewage at the joints not only fouls the earth in the neighbourhood, but it tends to choke up the pipe, as the solid matters left tend to block up the pipes.

Should these Private Sewers or Drains be allowed to pass under Houses?

No, not if it can be avoided, but in some cases it may be necessary on account of the configuration of the ground.

If they must pass under the House how should they be laid?

They should be laid under a passage or paved floor embedded in concrete, and carried from outside to outside. The pipes should be relieved from pressure by arches where the pipes pass under the walls.

What Course should these Drains take?

They should take a direct course to the common sewer; if that is impossible, then they must pass in straight lines from angle to angle, and at each angle inspection chambers ought to be placed. They should be laid on a firm bed to prevent sinking.

What is the Risk of Faulty Joints or Cracks?

On account of the warmth inside the house, the pressure of the air is less than the outside air, and the outside air will thus press the obnoxious sewer gases through the soil into the house.

What is the best Form of Junction with the Common Sewer?

The junctions should be CURVED and delivered in the direction of the main flow, and should enter ABOVE the

average level of the flow: it may be at right angles in manholes.

Why is this?

Because if the junctions be at right angles, the fluid entering is suddenly brought to a standstill in a series of eddies, and little hillocks of mud are deposited which retard the flow in the main sewer; they should open into the sewer at the upper part of its circumference, above the level of the flow, so as to prevent the sewage being backed into them from the common sewer. Further, if the end of the pipes from the houses were always under water, filth would subside and tend to choke up the private communicating sewers from the houses ("drains"). Still, if the opening be below the water line, the flow in the main sewer will trap it and prevent the entrance of gases to the house drain; but it must not be too low, otherwise the deposit of sludge that is apt to take place will choke up the end of the house drain.

What Inclination and Velocity should the Drains have?

They should be inclined so as to give a velocity of not LESS than 3 or more than 10 feet per second; in the case of the lower velocity, the best glazed pipes should be used. For 4-inch pipes a fall of 1 in 40; 5-inch 1 in 50, and so in progressive sizes.

What Size of Pipe should be used?

They need not exceed 6 inches in diameter; they are often less than this, but 4 to 6 inches is a fair size: the smaller the pipe the less fall is required. If the flow of sewage be faster than 4 feet per second, grit, stones, etc., are apt to cut and roughen the sides of the pipe.

What Point has to be attended to in connecting Water-Closets with the Common Sewer?

If possible, break the continuity of the drain between this and the common sewer by means of a special trap, with ventilation on the house side of the trap, so as to prevent effluvia from passing up the soil pipe into the house.

What do you mean by a Trap?

It is a name given to a bent pipe which lets water through, but stops gas or air, by means of a "water seal."

What Form of Trap may be used to disconnect the House Drain from the Common Sewer?

Buchan's Trap or an adaptation of it.

How should Sink Discharges be arranged?

The pipe should be trapped inside and should NEVER be connected DIRECTLY with the common sewer, but discharge in the open air over or under the grated covering of a trap or gully, just outside the wall of the house, and the trap itself should be ventilated by a special shaft or pipe. A trap is better than a gully, as the gully allows of a considerable amount of fluid to remain unchanged for a long time, and this is apt to decompose and produce gases that might pass up the pipe into the house. A gully, however, is useful to catch the greasy matters, which form a very great impediment to the discharge of sewage; or Field's flush tank may be used for the same purpose. The grease should always be intercepted before it enters the common sewer.

How are Gases from the Common Sewer kept from entering the House Drain?

Some use a light flap at the junction with the common sewer; but the ventilating shaft on the house side of the disconnecting trap will usually be found sufficient. If the pipe open below the level of the flow in the main sewer, it will be trapped and gases prevented from entering; but this should not be trusted to without thorough disconnection of the house drain close to the house.

Give the Size and Position of the Ventilating Pipes.

They should not be less than the diameter of the soil pipe, usually 4 inches; they should be carried up above the roof, and should not terminate near windows or close to chimneys, lest gases enter the house. The down pipes for the rain water should not be used as ventilators.

What Arrangements should be made for Flushing the House Drain?

Flush the water-closets well every time they are used; or the liquid refuse from sinks may be collected and discharged by Field's flush tank, which also acts as a grease interceptor. The rain water from the roofs and the waste water from the baths may be collected and emptied periodically into the house drain.

What Points are to be desired specially in a Water-Closet?

1. It must be so placed as to give rise to no bad smell in the house.

2. The fittings and trap must be good, so that no gases from the sewer, soil pipe or trap can escape into the house.

3. It should be made of enamelled ware, and have little woodwork about it.

How is the First Point best carried out?

The water-closet should be against an OUTER wall, or in a little projecting tower with free open-air ventilation, and with a lobby and ante-room, or passage with cross ventilation between it and the house, and have double doors—one for the water-closet and the other between the lobby and the house.

The water-closet should not be near dwelling-rooms, and NEVER in a bed-room.

It must have a cistern to itself, and must not take its water directly from the cistern containing water for dietetic uses.

The ventilating pipe must not be near bedroom windows, water cisterns, under the slates, nor near sky-lights, house ventilators, nor chimneys, because of the risk of effluvia.

The walls of the water-closet should be white. The apartment should be well lighted by windows; the scat-hole should be 1 inch less all round than the basin.

How is the Second Point best carried out?

The TRAPS—An efficient water seal of between 2 and 3 inches.

The VENTILATION—Continue the soil-pipe, full size, above the roof, as already explained.

NOTE. — Housemaids' sinks and waste-water pipes should open over a grating 2 or 3 inches above the level of the soil. More frequently the waste pipe terminates under the grating.

Name a specially Bad Trap and Water-Closet.

The D-trap and the pan-closet: a common faulty combination. They tend to collect filth, and are productive of effluvia.

NOTE.—(1) No cesspool for the detention or collection of putrefying liquid refuse should exist within or under any dwelling.

(2) No sewer or drain should pass under any dwelling, if it can possibly be avoided.

(3) All water-closet pipes should be properly ventilated and trapped.

(4) All pipes from sinks, slop basins, lavatories, baths, etc., should be disconnected from sewers, and should discharge through the outer wall of the house over or under the grated covering of the disconnecting trap or gully.

Should the Surface Water be admitted to the Sewers?

This would depend on the rainfall: this is greater and more frequent in the west as compared with the east part of a country. It may be admitted with advantage to flush the sewers. It will also depend on the fate of the sewage; if it has all to be pumped up a certain height, then the surface water should not be admitted. So also if it has to be cleansed by precipitation, etc., the surface water would make it too dilute. Also, if it is admitted, the great pressure might cause injury to the joints of the sewer. It is more important especially to exclude the surface water if the sewage is tide-locked for the greater part of the day, or where pumping is only carried on at stated periods, and where no reservoirs are provided during the night. In such cases, if a heavy rainfall is allowed to enter the sewers, all the small pipes are filled up and flood basements and cellars and low-lying parts of the town; and, besides, if the joints are bad, sewage escapes into the surrounding earth. The sewers being filled with water, too, forces the air in the sewers up to the highest parts of the town, and may force traps. It is

in this way that very often at fashionable sea-bathing towns the highest parts of the town, where the best houses are situated, are subjected to the uprising effluvia from the lowest parts. The foulest portions of the surface water should be admitted to the sewers, but the clean part should be sent into the river or stream.

Should the Road Detritus be admitted to Sewers ?

It is best to exclude it, because of the great expense of removal of the mud; it also makes it more difficult to treat chemically, and lessens the value of sewage as manure.

On what does the Quantity of Sewage depend ?

1. The population.
2. Local and special trades—*e.g.* paper mills and gelatine works require a large amount of water.
3. Sewage proper—the water supply.

How much Organic Nitrogen in Liquid Refuse is allowed to be poured into Rivers ?

Not more than ·3 in 100,000 parts.

Give Examples where this is apt to be exceeded.

Paper Mill Liquid contains,		76·816	parts	in 100,000.
Woollen	„ „	14·380	„	
Blanket	„ „	19·508	„	
Flannel	„ „	91·185	„	

What is the Difficulty in purifying these Fluids ?

Their extraordinary state of dilution; the only way seems to be land purification.

How does the Daily Discharge from Sewers vary?

One-half the daily outflow is discharged in four to six hours; the smallest quantity is discharged from 10 P.M. to 8 A.M., unless in mining districts where they work all night.

What Points have to be considered in fixing the Size of Sewers?

1. The maximum outflow.
2. The amount of subsoil water admitted.
3. The maximum amount of surface water to be admitted.

What are the Special Points in the Arrangements of Common Sewers?

1. All common sewers should be laid in straight lines whenever their sizes are not sufficient to allow the passage of a man to remove deposits.
2. They should have regular gradients from point to point; and where curves must be placed, increased fall to compensate for the friction.
3. In the streets they should occupy the centre, so as to be equally accessible from either side.
4. At the junctions of one common sewer with another, and in the case of all small sewers, at every change of direction and every change of gradient, there should be a shaft, or manhole, or lamphole, to be used for purposes of ventilation, flushing, inspection and the removal of obstructions.
5. Where sewers are so big as to allow a man to walk in them, they need not necessarily be straight.

What is a Manhole?

It is a hole to let a man down to the sewer and up again.

Where should they be placed?

At the junction of one common sewer with another, or at the concentration of several; at points where the angle of direction is changed, so as to examine and cleanse without breaking up the street.

What is a Lamphole?

It is a hole to let a lamp down to enable a man at the next manhole to see whether any obstruction exists, which may then be removed by flushing, or by means of a jointed rod. The flow can also be watched through the lampholes. Manholes and lampholes are also used to ventilate sewers; and if properly arranged no gas gets into the houses.

How often should they occur?

About every 100 yards—not LESS than this.

What Special Points must be attended to at Junctions?

The tributary flow must be delivered at such a height and in such a direction as not to interfere with the main flow; if unequal sectional diameters, they should not be at the same level, but the smaller should have a fall at least equal to the difference of the sectional diameter. If it is not above the level of the main, then the small side sewers will be back-watered, deposit taking place in the submerged part, so that it is choked by its own silt. Pipes of equal diameter should not be laid as tributaries —*e.g.* a 9-inch with a 9-inch, or a 6-inch with a 6-inch, but a lesser should be joined on to a greater—*e.g.* a 12-inch to a 15-inch, a 9-inch to a 12-inch, and a 6-inch to a 9-inch, etc. In new sewers side junctions for house drains should be provided, even though they may not be required when the sewer is constructed.

How deep should Subsoil Drains be?

8 to 10 feet deep.

How far should the Common Sewer be from the Houses?

It must be within 100 feet of every house included in the sewage system, according to the "Public Health Act."

In laying out the Sewage System of a Town, what should always be done?

There should always be a map made of the whole sewage system of the town.

What is the Ultimate End of all Sewage?

It must ultimately pass into the sea, a tidal river, estuary or inland river; the fall, therefore, must always incline in that direction, but before reaching the final outflow it must be purified from all foul and noxious matters.

Should the Sewage of Seaboard Towns be discharged into the Sea?

It should not be discharged into the sea—

1. If the sea is used for bathing or recreation.
2. If the town extends down to the water's edge.
3. Unless the town stands well above the sea, so that the outfall sewer may be carried far into the sea without converting such sewer into a large sewage reservoir.

What is a Great Objection to carrying Sewers into the Sea?

The sewage is impounded in the sewer during the time the tide is in. This is bad, as there may be generation

and evolution of gases through gullies, etc., into the streets and through traps into houses.

How is the Evil Effect of this evidenced?

The "cellar population" suffers very severely in such cases. It is worse in cases where the sewers are not watertight, therefore during the tide-locking, sewage must get out and soak into the soil, rendering it "excrement sodden" and constantly damp.

How is this to be corrected?

The sewage should be raised and disposed of above the tide level; or it should be PURIFIED—or at least clarified—before it is discharged into the sea, and a constant outflow should be secured independent of the tides. In all cases where the sewers are tide-locked, there must be some special means of ventilation.

What becomes of the Sewage discharged into Tidal Rivers and Estuaries?

It is carried out to sea by the ebb tide; and it would be better, therefore, if there were some temporary means of storing it, so that it could be discharged only during the ebb tide.

What is the Disadvantage of this Method of Disposal?

The banks become muddy, and in hot weather give off a very great stench when the tide is out; and this is much intensified when the mud is mixed with sewage. It is worse also in summer, when the flow of the river is diminished Pollution of shell-fish is very apt to result.

What is an Estuary?

It is the expanded mouth of a river, forming an arm of the sea, and extending inwards as far as the flow of the tide—so called because of the BOILING appearance when the tide flows up. A frith, or more commonly firth, is another name for the same thing.

What ought to be done in such a Case?

The sewage must be clarified, as well as purified, of all putrescible matters, although the purification need not be carried to so great an extent as if it were going to an inland river, because the water will not be used for domestic purposes.

What Degree of Purity is required in the Case of Treated Sewage?

1. It should be free from offensive odour.
2. It should be perfectly clear to the eye.
3. It should be neither alkaline nor acid.
4. It should not contain more than 60 grains of solid matters, when dried at 240° F.; and
5. Not more than ·75 grains of organic and ammoniacal nitrogen per gallon.
6. Not more than 2 grains of organic carbon per gallon.
7. And not less than 1 cubic foot of free oxygen per gallon.

But even with this degree of purity the water must not be used for domestic purposes.

What is necessary before the Sewage of Inland Towns be discharged into Rivers?

It must be purified from all foul and noxious matters by the best known practical means.

What Degree of Purity is required?

We should not admit to inland streams—

1. Any liquid containing in suspension more than three parts by weight of dry mineral matters, or one part by weight of dry organic matters, in 100,000 parts by weight of the liquid.

2. Not more than two parts by weight of organic carbon, or ·3 of organic nitrogen in 100,000 parts.

3. If 1 inch deep gives a colour against a white surface.

4. If there is more than two parts by weight of any metal except calcium, magnesium, potassium, or sodium in 100,000 parts.

5. If more than ·05 parts of metallic arsenic in any form in 100,000 parts.

6. If more than one part by weight of sulphur, as sulphuretted hydrogen.

7. If more than one part by weight of chlorine, after acidifaction with sulphuric acid, in 100,000 parts.

8. If the acidity is greater than two parts of pure hydrochloric acid to 1000 parts by weight of distilled water.

9. If the alkalinity is greater than one part by weight of dry caustic soda to 1000 parts of distilled water.

How can this Degree of Purity be obtained?

By using the soil itself as the purifier, either by—

1. Wide surface irrigation, commonly called broad irrigation.

2. Intermittent downward filtration pure and simple, or partly also by chemical means and then using the filtration.

In the case of villages and hamlets, it is easy to find land for the purification of the sewage.

What is meant by an "Intercepting Sewer"?

It is used to mean two things:—

1. The principal sewers cutting off existing sewers which discharge into a river at low level.

2. The sewer which divides the high ground from the low and keeps that portion of the sewage of a town which may be discharged by gravitation from reaching the lower parts of the town—the sewage of which has to be pumped up to the proper level or into the intercepting sewer.

Give an Example.

In London 27½ square miles are intercepted on the north of the Thames; lower than this, 25½ square miles have to be pumped up into the main sewer.

Where is Interception important?

In seaboard towns—*e.g.* Brighton—as much as possible should be intercepted and pumped and discharged above the tide. If the outfall sewer is made into a reservoir during the night, take care that it is not overcharged, and that it is provided with proper ventilation.

What Velocity is required to make Sewers self-cleaning?

It depends on the nature of the sewage.

60 feet per minute is enough for clear sewage.

90 feet per minute is required for strained sewage.

150 feet per minute is required for ordinary sewage.

Large sewers require 176 feet per minute when three-fourths full; 165 feet when one-half full; and 146 feet when one-third full.

30 feet per minute will not disturb clay or stones.
40 feet per minute will move along coarse sand.
60 feet per minute will move along fine gravel.
120 feet per minute will move along road pebbles.
180 feet per minute will move along angular stones about $1\frac{3}{4}$ inches in diameter.

What is the Bottom Velocity of a Sewer?

It is four-fifths of the mean velocity.

When do we get the greatest Discharge from a Sewer?

We get the greatest discharge from a circular conduit when it is fifteen-sixteenths full.

And the greatest Velocity?

The greatest velocity is secured by keeping it thirteen-sixteenths full.

What Fall should Sewers have?

A 2-feet sewer, with CLEAR sewage and a velocity of 60 feet per minute, requires a fall of 1 foot per mile or more.

If strained sewage be carried at a velocity of 90 feet per minute, it requires a fall of $2\frac{1}{2}$ feet per mile.

Ordinary sewage, at a velocity of 150 feet per minute, will require a fall of $7\frac{1}{2}$ feet per mile.

This shows the value of screening sewage, in cases of slight fall.

How would you calculate the Discharge from a Circular Sewer?

Find the velocity in feet per minute thus—

$$V = 55 \sqrt{R \times 2H}$$

R = hydraulic mean depth.
H = fall in feet per mile.
V = velocity in feet per minute.

Multiply the result of the sectional area of the pipe and this will give the cubic feet per minute and 1 cubic foot is = 6·25 gallons.

What is the Hydraulic Mean Depth ?

It is the sectional area divided by the wetted perimeter: in circular sewers it is always HALF the actual depth.

How do you find the Sectional Area ?

Square the diameter, and multiply by ·7854.

What are the Advantages of Egg-shaped Sewers ?

Egg-shaped are better than the circular when the flow varies from a small minimum to a large maximum. With the small quantity the small end of the sewer scours better, and the great size of the upper part affords space for the increasing outflow. If the minimum flow be one-half the maximum, so that the conduit is never less than half full, there is no advantage derived from the use of the egg-shaped sewer, since the circular are cheaper to construct and of greater strength.

What are the Forms of Egg-shaped or Oval Sewers ?

THE OLD FORM—

Vertical diameter = $1\frac{1}{2}$ times the transverse.
Radius of invert = $\frac{1}{4}$ the transverse diameter.
Radius of sides = $1\frac{1}{2}$ times the transverse diameter.

THE NEW FORM—

Vertical diameter = $1\frac{1}{2}$ times the transverse.
Radius of invert = $\frac{1}{8}$ the transverse diameter.
Radius of sides = $1\frac{1}{3}$ times the transverse diameter.

What Materials are used in Sewer Construction?

1. Bricks laid in cement or hydraulic mortar.
2. Stoneware pipes.
3. Concrete alone, or with bricks and pipes.
4. Iron pipes.

Under what Circumstances is Iron to be preferred?

At river crossings, and at sewer deflections, as in crossing from one side of a valley to another, in passing through unsound ground, and sometimes through closely inhabited districts.

How should Earthenware Drain Joints be made?

With gaskin well caulked in, and finished off with cement.

What is good Cement?

Portland cement of 110 to 112 lbs. to the striked bushel, and used in the proportion of one of cement to one of clean washed sand. Roman cement sets more quickly. Cement must be properly mixed and used AT ONCE.

What Kind of Bricks should be used?

The inner layer must be smooth, and all must be well burned and well shaped. Examples — London stock, Gault brick, blue Staffordshire, or fire-clay glazed on one side.

What Thickness of Stoneware Pipes should be used?

Well formed and well burned, and a thickness of not less than one-twelfth internal diameter; and in small sizes the thickness must be increased—*e.g.* a 4-inch should be half-an-inch thick, and an 18-inch about an inch and a half only.

How deep should the Joint Socket be?

An inch and a half in the smaller sizes, and two inches or more in the larger.

What are the Uses of Gullies?

To catch the surface water from the streets, etc., and retain the road detritus, permitting the water to pass into the drain or sewer, as it is cheaper to remove the road detritus and mud from the gully than from the sewer. Gullies must be trapped to prevent the escape of sewer gases.

What is a "Storm Overflow"?

It is an arrangement to act as a safety valve, connected with the intercepting or outfall sewer which it may cross at right angles; the opening into the sewer is so arranged that up to a certain point the storm overflow drops the whole of its contents into the sewer, but all excess is carried forward by its own velocity and inertia past the opening and emptied by the storm overflow into the river.

What is necessary when the Sewer ends in the Sea or a Tidal River?

A self-acting valve or flap should be placed at the end of the sewer, when it opens into the sea or a tidal river below high-water mark level, to prevent inflow of sea and keep out the wind which would drive back the gases. It must be truly balanced and self-acting and yield to the slightest pressure, close-fitting and face the sea. If some such plan be not adopted the low dwellings and cellars are apt to be flooded, as the sea will pass into the sewers.

What are the Objections to Charcoal Baskets for Sewer Ventilation and Deodorisation?

They are apt to be mixed with dust and become damp and lose their power unless very frequently changed: if too closely packed the charcoal impedes ventilation and when too loose and damp it is valueless: when too closely packed it stops the outflow of impure air.

What are the Best Means of ventilating Sewers?

It is best to trust to a sufficient number of manholes, lampholes, and shafts, assisted by manholes. Free circulation of the air in the sewers and incessant movement of the liquid are the best preventives of the generation and carriage of injurious products by means of the sewer gas. Some advocate the abolition of traps altogether, and invite the ventilation of sewers through the soil pipes carried full bore to the tops of houses.

What are the Effects of pouring Hot Water into a Sewer?

It is an extremely bad practice in unventilated sewers, as the hot water makes the air expand and forces traps; but if well ventilated, with free circulation of air, little or no harm will be done. It is illegal to pour large quantities of hot water into sewers.

What Effect has the Changing Volume of Water?

As the water rises the space is reduced, hence the gases are under great pressure and may be forced out through traps, etc. When the water level falls a tendency to a vacuum is produced. This tends to unseal traps. The great importance, therefore, of having free ventilation in the sewers will be at once evident—

1. To get rid of foul gases.
2. To prevent their generation.

3. To let out the air, when the space is lessened by hot water or increased flow.
4. To let in fresh air, when the space is increased and the water cold.

What is the Amount of Fæces and Urine voided by a Population of 1000 *Persons?*

Daily—

Fæces, 156 lbs.
Urine, 250 gallons.

Yearly—

Fæces, 25 tons.
Urine, 91,250 gallons.

What are the Objections to the old-fashioned Middens and Privies?

They favour the spread of cholera, enteric fever, and diarrhœal complaints: they pollute wells; their contents soak into the soil round about and pollute the air; the materials also decompose, and this lessens their agricultural value.

How may the Bad Effects be lessened?

In villages, if they MUST be used, they should be water-tight, and small, so that they must be frequently cleared out. If the receptacles are movable, they are not so objectionable if properly looked after.

What is the "Pail" System?

Where the excreta are caught in pails or shallow tubs containing some absorbent material or deodoriser, and often and regularly removed by the Sanitary Authority of the place. The pails may contain chemicals; they are emptied into a trench formed of fine ashes, with 30 lbs.

of sulphuric acid to the ton, and the whole well mixed. In three days it is turned over with a spade, and again in twenty-one days, and after this it is pretty dry; it is then screened and sold as manure. This form of excrement disposal is nowadays seldom employed.

What is the "Goux" System?

It is a special form of the pail system. A shallow tub or pail is lined with stable litter, loft sweepings, shoddy, sawdust, spent tan or hops, mixed with soot, charcoal, crude ferrous sulphate or gypsum. A layer 4 inches thick is first laid in the bottom; then on this a mould, 6 inches less all round than the tub or pail, and then the material packed into the space at the side all round and the mould removed, leaving a hole. The tubs are $16\frac{1}{2}$ inches high and 20 inches wide at the top. The prepared pails are distributed to the houses, and the others removed every two days: it is necessary that the Sanitary Authority should look after them.

What is Moule's System?

It is one form of the dry-closet system; dry earth is made use of to cover and deodorise the excreta. It consists of a wooden box, with a pail beneath, a reservoir for the earth above and an apparatus for measuring and delivering the proper quantity of earth every time the closet is used; the earth must be dry and loose.

How much Earth is required?

About $1\frac{1}{2}$ lbs. for each stool, inclusive of the urine passed with the stool: the rest of the urine, and the slops, etc., must flow away by some other channel. If the urine too is to be caught, then it will require 4 lbs. of earth every time the closet is used.

When is this System specially suitable?

Public establishments, private estates, and villages: it is not suited for large towns. For villages, where the earth is easily got, it is very good; and in country houses the earth may be dried and used again. Charcoal could be used, and then it would only need one-fourth the quantity; but it is too dear and difficult to get.

What Forms of Earth are best?

1. Rich garden surface mould.
2. Peaty soils.
3. Black cotton soils.
4. Clays.
5. Stiff clayey loams.
6. Red ferruginous loams.
7. Sandy loams.

Sand and gravel—the worst of all, and almost useless: chalk is also of very little use.

What are the Objections to Moule's System?

1. The trouble of providing a sufficient quantity of dry earth of the proper kind—at least 1½ lbs. for each dejection; and for urine as well, 4 lbs. are required.
2. The expense of cartage in bringing the earth into the town and removing it again.
3. It is offensive to the sight.
4. Difficulty of securing proper attention to the working of the closets.
5. Small value of the resulting manure—£2 to £3 per ton.
6. The excreta are retained in the neighbourhood of the houses.

What are the Advantages of the System?

1. It is cheaper in the original cost than water-closets.
2. It requires less repair.
3. It is not injured by frost.
4. It is not damaged by improper substances being thrown into it.
5. It reduces the amount of water required by each household.

Special means must be provided for the removal of slops, rain water, and soil water.

Name a Modification of this System.

Morrelle's plan of using riddled cinders, such as can always be got from ordinary coal fires; the result, like the last, is then worked up into manure.

All such closets must be managed by the Sanitary Authority of the district. Ashpits and dustbins must also be carefully attended to; they should be protected from the sun and rain, well ventilated and small in size, watertight, and be very frequently cleaned out. All cesspits must also be perfectly watertight, if they are to be used at all, and even then all wells used for domestic purposes must be at least 100 feet from any such cesspit, privy, etc.

What is the Best Means for the Disposal of Liquid Sewage?

By using the land itself; earth is a good deodoriser, and a good purifier if sewage be passed through it intermittently, so as to allow it time to be aerated and oxidised. The growth too of grasses and vegetables gives a good return for the primary outlay and working, and the land steadily increases in value from year to year; of course the amount of profit will depend a good deal on the

demand for succulent grasses and vegetables. But the earning capacity must be a secondary consideration, sewage purification being the first.

What is the Theoretical Manurial Value of the Excreta?

An adult gives off in excreta 16·41 lbs. of nitrogen yearly, which is sufficient to yield 800 lbs. of wheat or 900 lbs. of barley. Liebig says that one can give enough nitrogen for sufficient manurial matter to raise from an acre of ground the richest possible crop every year. Besides the combined nitrogen—which is the measure of the manurial value—we have phosphates, which are also very valuable.

What is the Actual Monetary Value?

This is measured by the combined nitrogen. About 12½ lbs. of ammonia is produced per head every year; this is worth about eightpence or ninepence per lb. About 5½ lbs. of phosphates are produced per head per year; worth about twopence per lb. So that the actual monetary value of the fæces and urine of England and Wales alone is equal to £5,000,000 every year.

The urine is about six times as valuable as the fæces from a manurial point of view. Chemical processes for the disposal of sewage are about from four to six times more expensive to the ratepayers than by using the land itself.

What are the Drawbacks to Sewage Farming?

1. The outflow of sewage is constant, and must be disposed of without nuisance, night and day, Sunday and Saturday, all the year round.

2. The special character of the produce growing therefrom.

3. The farm requires a large amount of labour and a large outlay of money.

4. The home market for the produce is limited; and

5. If transported to distant markets will not pay, and the larger the area of soil utilised the greater the loss.

What Crops are best fitted for Sewage Farms?

Fast-growing succulent grasses and market-garden vegetables — *e.g.* Italian ryegrass, mangolds, swedes, carrots, parsnips, cabbages, potatoes and onions.

What are the Solid Matters of Sewage?

1. Bulky substances that can be removed by screening, as corks, sticks, dead cats, etc.

2. Substances that quickly sink of their own weight, as road detritus.

3. Very fine substances which are not deposited when the sewage is in motion, except by adding chemical precipitants; when left at rest, it is deposited slowly, and this = "sludge."

What are the chief Precipitation Methods?

1. By adding lime, 12 grains to the gallon, stirring it and then allowing it to settle; by this plan the ammonia is lost and the solid matters are left in the water.

2. By adding the coarse salts of iron or aluminium, with or without lime.

3. Lime and clay.

4. The A B C process—alum, blood, and clay and charcoal, or crude aluminium sulphate.

5. Lime and prolosulphate of iron.

6. Lime and black ash waste.

7. Lime and herring brine (Amine's process).
8. Ferrozone.
9. Sulphate of iron.
10. Peroxide of chlorine (Howatson's process).

Describe the A B C Process.

When the aluminium sulphate or alum is added, the alkaline liquid decomposes it and forms the hydrate of aluminium, and this attacks the nitrogenous matters, but being very light, clay is added to make it sink. The carbon is added to absorb and decompose foul gases. Lastly, a little sulphuric acid is added to the mud to fix the free ammonia, and the whole dried in hot revolving cylinders.

What is the Phosphate of Aluminium Process?

Phosphate of aluminium and calcium are added to the sewage. The aluminium curdles and coagulates the fæcal matters; the calcium draws the soluble phosphates from the sewage and forms a precipitate, which carries down the coagulated fæcal matters. It is then left in tanks to settle and the clear water allowed to flow off, while the solids are dried. The water is not fit to be passed directly into rivers.

What is the Sulphate of Aluminium Process?

The crude sulphate is prepared from clay by adding sulphuric acid—two pints of clay and one of acid. This is mixed well and placed in a warm place to dry, and then it is added to the sewage in a tank in the proportion of 1 lb. to the 100 gallons, or 4 tons to the million gallons. To this is added common lime, the aluminium hydrate is set free, and sulphate of calcium is formed; the precipitates fall to the bottom and carry the sewage with them.

What is the "Scott Sewage Company"?

It is burning the combustible parts of the sludge in the manufacture of cement and limes. Slaked lime is added to the sewage, and this causes a precipitate of the carbonates, phosphates, and silicates; then clay is added to combine with the silica and the alumnia: the precipitate is removed from the tank and dried and then burned in kilns—once it is begun its own organic matters are enough for fuel to burn it. The result is then ground to a fine powder, the product being 2 tons of Portland cement from one million gallons of sewage.

What is Liernur's System?

It is the "pneumatic" system. The town to be treated is divided into districts of from 200 to 1000 houses, and each district is provided with an air-tight iron tank about 3 feet below the surface. This tank is connected with the closets of the houses by air-tight pipes. In the centre of the town is placed a central station, with air-tight reservoirs and engines for pumping out the air: the station is connected with each district tank by a separate system of air-tight pipes. The pipes and tanks are exhausted by the engines, so that the excreta are drawn or rather forced to the central station by the atmospheric pressure: at the central station the excreta are converted into a dry powder by means of the exhaust steam.

Where is this Plan used?

In towns in Holland, Prague, Olmutz, and St Petersburg.

What are its Advantages?

1. The pipes are emptied daily.
2. They are all 5-inch cast-iron pipes, with lead and tow joints.

3. There are no valves, only cocks that can be easily examined.

4. Closets are without water, are funnel-shaped, and ventilated from the funnel, with another ventilating shaft from the soil-pipe.

5. Pipes cannot be blocked by improper substances being thrown down.

Means must be provided for removing sink refuse and liquid refuse of trade by another set of pipes; as well as the rain and subsoil water.

There is no pollution of air, water or soil.

What is Webster's Method?

Treating the sewage by means of electricity; the current is passed through the sewage in the tank: in this way gases are formed that carry the solid matters to the top. The fluid is then agitated, the gases pass off, and the solid parts settle to the bottom without any tendency to diffuse through the fluid again.

When should these various Artificial Methods be used?

Only when land cannot be obtained for the disposal of sewage. Frost is no bar to its disposal by land, as the average temperature of the sewage is higher than the outside air, so that it will thaw the frozen land—the temperature in the sewers being higher, especially in winter and autumn. The land purifies the sewage, which in its turn fertilises the land; the soil acts as a filter, and then the oxygen in the earth and vegetation on the soil destroy sewage and its products by chemical and bacterial action.

What is "Wide Surface or Broad Irrigation"?

It is a method for the disposal of sewage by using the soil itself—*e.g.* irrigated meadows, as at Craigentinny.

The sewage is spread over a wide surface without precise regard to its REGULAR absorption and infiltration. The land should not be flooded, but such a quantity used as will satisfy vegetation without waste, and the absorptive powers of the soil without overflow. The land, too, ought to be underdrained at about the depth of 6 feet from the surface, as this will remove the purified liquids and also aerate the soil, otherwise it is apt to become a huge morass or swamp, oxidising powers of the soil being impeded if not destroyed.

What is the best Site for a Sewage Farm?

All sewage farms should be laid out on slopes; and the land must not be too retentive or too porous, clay soils being avoided.

How much Land is required?

An acre for every 100 persons of prospective population.

What Crops are best?

Usually Italian ryegrass.

Name Suitable and Unsuitable Soils.

SUITABLE—a soil naturally fertile gives the best and quickest returns: the BEST is loam, with a small proportion of gritty gravel to allow of percolation.

The WORST soils are stiff clays, coarse gravels and boggy peat lands; the clay cracks, and the raw sewage runs into the cracks and fills them up. If well underdrained and prepared, clay might, in the absence of any other soil, be made to fulfil the purpose, as at Harrogate and Earlswood. But if such land is undrained, the sewage often runs off unchanged. If the soil be too free, it is also bad, as sewage runs through it too quickly—*e.g.* Heathcote

Farm, Leamington, where each acre receives from 10,000 to 15,000 tons.

The best soil then for wide surface irrigation is a fairly free soil, with a small proportion of clay to moderate its percolative powers.

How much should each Acre receive?

Fifty tons is enough to fertilise a growing crop.

What Depth is that over the whole?

Half-an-inch deep over an acre is = 50 tons, and 1 inch is = 100 tons (or 101 tons, less 2 gallons)—*i.e.* 1 inch deep over an acre is = 22,622 gallons, and 1 ton of water is = 224 gallons, and 1 gallon = 10 lbs.

What is the Use of Underdraining?

To prevent waterlogging and to allow the soil to be properly aerated.

How many Subsoil Drains should there be?

If the soil be porous only few drains; if retentive, many are required. In clay soils they must be as numerous as possible.

What Surface Preparation is required?

DELIVERING CONDUITS from the outfall sewer, with TANKS sometimes, to separate the coarser parts of the sewage; and SLUICE CHAMBERS, to direct it at various points from the delivering conduits into the DISTRIBUTING CARRIERS, which are formed by the ground itself: in these carriers there must be STOPS of metal or wood, to direct the flow and supply all parts of the soil evenly.

What are the Different Modes of distributing the Sewage?

1. The "catch-water" system.
2. The "pane and gutter" system.
3. The "bed" system.

What is the "Catch-Water" System?

There is a series of carriers following the contour lines of the ground, one under the other, with just sufficient fall to carry the sewage forward; by the help of stops, they distribute the sewage over the land, and also "catch" the water that flows off from the part above, and so on, and this water may pass over several. Even at the last it is not all absorbed, and some may find its way into the stream uncleansed. This plan is well suited in cases where Italian ryegrass is chiefly grown; but with stiff clayey land, and in wet weather, it may flow off very impure.

What is the "Pane and Gutter" System?

The ground is divided into wide beds, with but little fall, and is fed from the top by gutters traversing its surface, with panes so as to allow of even distribution. In this plan there is often a good deal of waste, where the beds are large; and if uneven, the sewage collects in pools, evaporates and leaves the sludge, and creates a nuisance. Very often, too, large quantities are used by this method—*e.g.* 15,000 to 20,000 tons per acre, which is far too much.

What is the "Bed" System?

The land is formed into ridges and furrows in parallel straight lines, with carriers or gutters along the ridges, with STOPS at the sides to let the sewage out: the width

of the "beds" is from 30 to 150 feet, and the slope of the surface from 1 in 25 to 1 in 150.

Describe another and better Plan of Sewage Distribution.

It is better that the sewage should not pass over the SURFACE at all, but should pass down furrows between NARROW ridges formed by the hand or a double mould board plough. Crops are grown on the ridges, and the space between is just sufficient to separate the rows of plants from each other, and the sewage soaks in close to the roots of the plants. When the crops are removed the narrower ridges are split up by the double mould plough, and the whole field laid out flat for the growth of other crops, as wheat, oats, pulse, etc. The narrow ridges of course are no good for the growth of ryegrass, but are specially fitted for the growth of roots and vegetables.

What is "Intermittent Downward Filtration"?

The land is divided into four equal parts, each part receiving the whole sewage for six hours out of the twenty-four.

By this plan water-closet towns of 10,000 could be dealt with on 5 acres, provided the ground be well underdrained to a depth of 6 feet.

In this way the land is like an immense lung, filtering and oxidising, alternately receiving and expiring air; each part rests eighteen hours out of the twenty-four, and in doing so drains itself and becomes refilled with air. By this plan a cubic yard will cleanse $4\frac{1}{2}$ to 10 gallons in twenty-four hours.

What are the Objections urged against this Plan?

Dr Frankland, who first suggested the method, gives the following objections—

1. There is no profit.

2. The manure is all lost.

3. The solids collect on the surface, and cause a nuisance in hot weather.

How is it conducted?

1. Three areas instead of one are in constant use, each being capable of cleansing the whole sewage.

2. The areas are divided into ridges and furrows, and the sewage is run into the furrows for one year at a time, and then each remains free from sewage for two years in succession, being devoted to plant growth.

3. On the areas actually in use, crops of succulent vegetables are grown.

4. The area in use is so divided that one-third or one-fourth of the sewage shall be applied to it for a fixed period each day, so that there is a daily intermittency as well as a tri-yearly one. The ground is well under-drained 6 feet down.

How much Land is required for this Plan?

One acre for every 1000 or 1100 of the inhabitants.

Compare "Wide Irrigation" with "Intermittent Downward Filtration."

WIDE IRRIGATION means the distribution of sewage over as many acres as it will wet, without super-saturation, having in view a maximum growth of vegetables for the amount of sewage applied.

INTERMITTENT DOWNWARD FILTRATION is the concentration of sewage at short intervals, on as few acres of land as will absorb and purify the sewage, keeping the production of vegetables at the same time in view.

Should Clay Soil be used?

Not if possible, and if it must be used then it should be trenched for 2 or 3 feet down and mixed with cinder ashes, chalk, sand or gravel, to make it more porous.

What about the Underdrains?

If in free soil, they should be deep and few—the deeper they are the more perfect the filtration; they should be under the banks and barrow paths, and not directly under the furrows, and 6 or 7 feet down; hence under every square yard there will be 2 cubic yards of filtering material = 9680 cubic yards per acre.

How much will an Acre cleanse?

Every cubic yard cleanses from 4 to 12·4 gallons per day, so that a single acre will cleanse from 40,000 up to 124,000 gallons per day.

What Surface Preparation is required?

It should be made roughly level, so that the sewage may be applied evenly and divided into ridges, with furrows between. The width of these will depend on the nature of the soil; the more level the better for intermittent downward filtration. It is well to have ventilating shafts at the junctions of the drains. These assist in aerating the soil, and also indicate the levels of the subsoil water.

Give a Résumé of the various Plans for dealing with Sewage.

1. In small rising towns, may use the "double system" of sewers: the sewage is not diluted, and can more easily be used up, while the rest of the foul water can be returned to the river.

2. Passing the sewage into the rivers: now illegal.
3. Liernur's system (pneumatic).
4. Precipitation methods—
   (1) By lime.
   (2) Coarse salts of iron and aluminium.
   (3) Phosphoric acid and phosphates.
   (4) The A B C process. (See p. 34.)
5. Using the soil itself—the best of all.
   (1) Irrigated meadows—wide surface irrigation.
   (2) Intermittent downward filtration.
6. Cameron's septic tank.
7. Dibdin's contact beds.
8. Scott-Moncrieff's system.
9. Stoddart's system.

What are the main Principles involved in Cameron's septic tank?

Sewage is led to a grit chamber, where the grosser solids are arrested. The next stage shows the sewage passing into the septic tanks, which are long and narrow in order to encourage a tardy flow of sewage between entrance and exit. In these tanks, which are air and light tight, anærobic organisms are at work upon the sewage. The liquefaction and digestion of sewage is a slow process. The liquefied portions pass out of the tank, and are conveyed to a trough, over the edges of which the sewage falls in a thin stream. This treatment oxygenates the sewage. After this the sewage, more or less purified and aerated, is passed to chambers in which an alternating gear is situated. This gear diverts the sewage, in rotation, from one filter bed to another. These filter beds are filled with clinker secured usually from refuse destructors. After the sewage has remained in contact with the clinker in the filter bed for several

hours the micro-organisms in the interstices of the filtering medium have further purified the sewage, which may then be run off and diverted into a stream or be subjected to another purification process by land treatment.

Wherein do other Methods differ from the foregoing?

Only in minor details. The main idea of anærobic action of bacteria with subsequent operation of ærobes is at work in Scott-Moncrieff's, Dibdin's, Stoddart's and other methods.

What are the Objects of Sewers?

1. To drain the surface.
2. To drain the subsoil.
3. To remove fæcal and liquid refuse.

NOTE.—Before 1815 it was illegal to allow sewage to pass into rivers: in 1847 an Act was passed to compel the passage of sewage into rivers; and at the present day it is not lawful to pass sewage into rivers until it is purified by the best practicable and available means.

What Points have to be considered in sewering a District?

Consider—

1. The area of the district to be sewered.
2. The rainfall, and the proportion to be admitted into the sewers.
3. The geological character and the physical outline of the district.
4. The present and prospective population.
5. The water supply.
6. The sanitary appliances to be adopted.
7. The position of the outfall, and the mode of disposal of the sewage to be adopted.

What Authority is required?

The Local Government Board, by provisional orders, when sanctioned by Act of Parliament, can compel the execution of sanitary works. If the works extend into the sea way, then the assent of the Admiralty must be gained.

What are the Results of Sanitary Works?

1. Lessened death-rate.
2. Improved health and physical ability.
3. Natural prosperity.
4. Increase of health, which is capital, and less sickness.

What are the Three Chief Desiderata in Hygiene?

1. Pure air, and plenty of it.
2. Pure water, and plenty of it.
3. Rigid cleanliness of person and house.

Should the Rainfall be admitted to the Sewers?

Small rainfalls give very foul water, and should be admitted; large, give pure water, and probably should be excluded. For this purpose a "storm overflow" should be provided, so that the water when the velocity is great is shot past the opening into the sewer, but when the velocity is low then it falls into the sewer. The water spouting from an orifice forms parabola, and when the velocity is great the space fallen through is small, and when the velocity is small the space fallen through is great, as it is longer exposed to the influence of gravity. The rain is a scavenger of streets, courts, yards and roofs; and when the rainfall is small it is as foul as sewage.

What are the Objections to admitting the Rain Water?

1. When the sewage has to be pumped it dilutes it too much.

2. If the sewage has to be treated chemically, it is better to exclude it.

3. Also probably in towns with tide-locked sewers, it should be excluded.

Storm and spate waters should be excluded, as they might burst the sewer, or, if made large enough to accommodate the spate and storm waters, the sewers during droughts would be far too large and would deposit sludge. If surface water pollutes rivers, the Sanitary Authority is held responsible. Much of the rain water is absorbed into the soil and a good deal of it evaporates from the surface, so that it is only a certain percentage that will enter the sewers. In gravelly and chalky soils it is almost all absorbed; if the district be steep, much runs off and finds its way to the sewers, and little is absorbed.

What is the Objection to too steep Gradients in laying out Sewers?

If the gradients are steep the sewers act like chimneys, drawing off the foul gases from the lower parts and dispersing them to the higher parts.

Do Water-Closets increase the Amount of Sewage?

The great consumption of water is due to the imperfect fittings; the water-closets themselves do not materially increase the water supply, nor do they increase the volume of sewage of the towns. The sewage of midden towns is almost as great as in water-closet towns; there is more chlorine in a given volume in midden towns.

What is a Sewer of Deposit?

The old sewers were sewers of deposit, and very soon became choked up, and had to be made large enough to let a man in to clean them out.

How was this?

It was due to faults in size, form, mode of construction and materials. The inverts were flat, the walls rough, corners numerous, the flow was small and the velocity slow, the joints were leaky. These conditions must be reversed in order to secure "self-cleansing sewers."

What Velocity should be allowed in Sewers?

In no case less than 2 feet per second, and usually much greater: house drains should be $4\frac{1}{2}$ feet per second. Pipes of 6 to 9 inches in diameter need a velocity of 3 feet per second; pipes of 12 to 24 inches need $2\frac{1}{2}$ feet per second—the smaller the sewer the greater the fall.

How much Fall should be allowed?

A 10-foot sewer needs a fall of 2 feet per mile.
A 5-foot sewer, 4 feet per mile.
A 2-foot sewer, 10 feet per mile.
A 1-foot sewer, 20 feet per mile.

If a sewer is not self-cleansing, it must be flushed occasionally by means of automatic (underground) flushing tanks.

What is the Cause of Motion in Sewers?

Gravity is the sole cause of motion. The resistance is caused by the bed and sides of the sewer: the nature of the materials makes little difference, because in every case it becomes covered by a thin film of water, so that the friction is between two layers of water.

What is the "Wetted Perimeter"?

The part of the pipe touched or wetted by the water.

How is the Resistance measured?

It is inversely as the section of the pipe, and directly as the velocity.

What is the Hydraulic Mean Depth in a Circular Sewer?

When it is full or half full it is always one-fourth the diameter of the pipe or tube.

Should Sewers be laid at the Back of Houses?

No, not as a rule. It is more economical to the Local Authority, and safer, to place the public sewers in public thoroughfares than in private land at the back of houses. If laid in the back yards, they could not be in straight lines, and the manholes, etc., would interfere with the rights of private property; besides, the Local Authority has no right to enter private property. Exception, however, arises when nuisances are suspected to exist. In such cases warrant may, if need be, be secured to enter private property.

When are Intercepting Sewers necessary or advantageous?

Often necessary to make the works pay. When the district has a small longitudinal but no lateral fall. May be necessary for the safety of large districts, as the volume of sewage or rain water can better be brought under control than when the district is large and all is allowed to fall to the lowest level.

Also in sea-coast towns, where the lower sewers are tide-locked.

Can also be used in districts that overgrow existing sewers.

What Conditions ought a Sewer to fulfil?

It ought to convey the sewage with maximum velocity, both minimum and maximum flows, and be strong enough to resist the weight of earth above and at the sides. The circular form is the cheapest, and may be used where the flow is uniform. In general egg-shaped sewers are employed.

Should Gas Pipes be laid in the same Drains with Sewage Pipes?

It is better not. In Paris both gas and water pipes are placed in the subway of the sewer; but the gas pipes are dangerous from the risk of leaks, when explosions may occur when a light is carried in by the workmen.

What is a "Small" Sewer?

From 9 to 18 inches in diameter: these are best constructed in earthenware or concrete, and made circular.

What Size should be adopted?

No sewer should be less than 9 inches in diameter, because if less it is very apt to be choked up: the number of blocks or stoppages are greatest in the small ones, and least of all in the 9-inch sewers.

Of what Materials should the Pipes be made?

Fireclay or stoneware; of which, the latter is the better material of the two. They should be impervious, uniform in thickness, tough and strong, true in section and perfectly straight, glazed inside and outside, and free from cracks of all kinds, and should give a clear ring when struck.

What is the best Glaze to use?

Salt glaze is the best, because it goes through the whole thickness of the pipe; whereas lead and glass glaze merely varnish the surface.

Why should they be impervious?

To prevent—

1. The entrance and crystallisation of water in times of frost.
2. The formation of crystals in the interior in presence of certain chemical compounds.
3. The direct chemical action of materials found in the sewers.

How would you test the Impermeability?

Dry a part of the substance till it ceases to lose weight; then steep in water for twenty-four hours and then wipe, dry, and re-weigh; the best pipes absorb the least.

How would you test their Chemical Resistance?

Pulverise a small piece and boil it in hydrochloric acid, and note the loss of weight. The clay should contain no lime, because this when moist renders the pipes rotten.

How should the Pipes be laid?

The spigot end of the pipe is to be laid into the socket of the other, and the spigot end directed or laid DOWNHILL. The socket and pipe should be made in one piece. The pipe must rest throughout its ENTIRE LENGTH on the ground, so that it is necessary to cut out a small depression to hold the socket, or else carefully pack up the part under the pipe, to give support. Cement joints should be used, and the pipes must be carefully held till it sets, and

see that none passes into the pipe and so roughens the interior. When the sewer is conveyed under a dwelling, the pipes should be laid in asphalt or in cement. If the pipes merely rest on their two ends, the pipes become girders and break from the weight of earth above. Sewers with vertical or straight sides require 50 per cent. greater thickness than curved ones of the same dimensions.

What are the Objections to Ordinary Mortar in Sewer Building?

1. The ammonia becomes oxidised into nitrous and nitric acids, and forms soluble compounds with the calcium, which is then washed away.

2. The carbonic acid in the sewage makes it take up some of the lime in solution and removes it, so that only sand is left, and the sewers therefore fail. Hence, therefore, always test the mortar or cement by nitric acid before using; let it stand for ten days in a 10 per cent. solution, and it will be found that Portland cement is the best.

In flushing Sewers where would you begin?

Always begin at the lower parts of the district first, and gradually work your way to the higher parts.

What are the Effects of Heat in Sewers?

It expands the air, and if the sewer is not properly ventilated may force traps and leave them unsealed. The temperature varies with hot liquids and seasons.

In sewers the—

Summer temperature is below that of the atmosphere.

In spring it is just equal to it.

In autumn and winter it is above the temperature of the outside air.

Hot water expands the air and also heats the other water present, and makes it less able to hold the foul gases in solution; hence, a rise of temperature makes the air of sewers offensive.

What are the Effects of the Ebb and Flow in Sewers?

It leaves the sides of the sewers alternately wet and dry, and thus leads to the production of vapour, and compresses the air or allows it to expand as the case may be, and will force the traps if there is no proper ventilation. Sewers from morning till noon are expelling foul air, due to the "flow"; but from noon till morn they are drawing in fresh air—the "ebb." Sewers discharging into the sea or tidal rivers are apt to be tide-locked twice a day, and fill with sewage, so that the gas is forced out; and then during the ebb the air is drawn in. These fluctuations, due to ebb and flow, make it necessary that the sewers should be properly ventilated.

What Effect have Barometric Changes on Sewers?

When the barometer falls the pressure is less; there is an escape of sewer gas, and this favours decomposition; an increase of barometric pressure (when the barometer "rises") enables the air to carry more watery vapour, and the sewage also retains a larger volume of offensive gases in solution. A rapid fall liberates foul air from the sewage. This partly accounts for the bad smells felt in the streets and elsewhere. Sewage at a high level contains air of less tension than sewage at a low level, and therefore in passing from a higher to a lower level it tends to take up more air; hence FLOWING sewage tends to retain foul air in solution.

Give a List of the Forces acting in Sewers?

1. Gravity, the cause of the flow.
2. Heat, from hot liquids, etc.
3. The force of the ebb and flow.
4. Barometric changes.
5. Wind blowing up outfall sewer, the end of which, therefore, should be protected.
6. Friction and leakage.

What is the Objection to ordinary Ventilating Shafts?

They do not act well if the heat of the outside air be greater than the air in the sewer. At the season when ventilation is most required—*i.e.* in summer—ventilating shafts are almost useless.

Could we use the Chimney Shafts of Manufactories?

They might be used but there are many objections—

1. It spoils their use as chimneys.
2. They must be larger than the manufactory requires.
3. They are inPRIVATE hands.
4. They are useless when the fires are out, as on holidays.
5. The gas being often combustible, it may lead to explosions.

Occasionally this plan is useful for the PARTIAL ventilation of sewers, or of the sewage tanks at pumping stations. Lamp columns may be used with advantage as ventilating shafts.

Should Rain Water Pipes be used for Sewer Ventilation?

No; in any case they would only be of use for house drains, for in times of rain the end of the house drain is

covered in the sewer, so that gases could not get up. The water, too, in the rain pipes would absorb the gases and carry them down. Further, these pipes are under the eaves of houses and may be near windows, so that gases could gain admission to the houses. It is better to have short shafts of large area in the streets; they are as good as small ones of great height, and even better, as there is less friction, and less pressure exists in the sewers behind them.

What is the Objection to Ventilating into the Streets?

It is bad in narrow streets and confined places; the great safeguard is free dilution of the foul air with the fresh outside air. In such places upcast ventilating shafts ought to be used.

How may Water Traps lose their Seal?

1. The water may dry up.
2. The pipe may run full bore, and run past with such velocity as not to remain in the bend at all.
3. It may be sucked out by a mere rag lying over the edge, as a bit of dust cloth, this acting like the wick of a lamp.
4. It may be forced back by pressure inside the sewer, for expansion of gases, etc. To these must be added bad construction, insufficient dip, and inefficient ventilation.

To remedy this, flush the traps frequently, and have free ventilation on both sides of the trap.

What is an Antisyphonage Pipe?

It is employed to prevent the unsealing of the traps in connection with water-closets. An antisyphonage pipe is usually provided when there are several closets in series, one over the other. If no antisyphonage pipe

were provided the simultaneous flushing of one or two closets might "suck out" the seal of one or more of the lower closets.

How does a Firth or Tidal River differ from the Sea?

In tidal rivers and firths the ebb is much longer than the flow, and therefore it is much better for the carrying away of the sewage.

What is a Penstock?

It is a sluice fixed in a sewer to regulate or control the current—*e.g.* to stop the flow and pen up the sewage for flushing purposes. It is necessary in tidal outfalls as an adjunct to tidal valves; it is also used to direct the sewage from one line into another.

When are "Tank Sewers" necessary?

They are necessary when the sewers are tide-locked, and sometimes when pumping is necessary; also in discharges into tidal rivers, to collect the sewage during the flow tide, and discharge it during the ebb tide, as this carries the sewage away. They are formed by enlarging the outfall sewer or some convenient branch sewer, to store up the sewage for the time required. Sometimes reservoirs are used instead, but tank sewers are better, though they take a little longer to empty.

When are Inverted Syphons used?

They are used in carrying the sewage across navigable rivers, streams, or valleys, and should be self-cleansing; they should have a wire rope or chain in the interior, so as to stir up any sludge that may settle.

What is necessary when the House Drains come through the Wall?

They must have ample space, the part being protected by an arch not resting on the pipe; if not, the pipes often fail in new buildings, being broken by the "settling" of the walls of the house. The pipes should be of iron, and may as an additional protection be bedded in cement.

What are the best Pipes?

Glazed stoneware. Sewer air and bits of lime will soon corrode LEAD pipes; IRON pipes become coated inside with a layer of oxide, and fæcal matters adhere to it. ZINC pipes are now seldom used as they are very soon corroded by the chemical action of the fæcal matters.

PUBLIC HEALTH

VITAL STATISTICS

What is meant by this Term?

It is the scienee of figures applied to the health history of eountries, and the study of the laws that govern the physieal condition of mankind. It deals with births, marriages and deaths, the diseases from whieh we die or suffer, and takes into eonsideration age, sex, oeeupation of individuals, as well as the diseases.

What are the Sources of Information?

1. The eensus returns.
2. Returns of births, marriages and deaths by registration.

What are the Uses of Vital Statistics?

1. They give information as to the health of the people and the good or evil eonditions affecting the people.
2. They enable us to apply the above information to Life Assuranee.
3. They show the fatality of different diseases at different ages.
4. They show also the influence of professions, trades, loeality and age on the well-being of the eommunity.

What is the "Census"?

It is the actual enumeration of the population.

How often is it taken?

In Great Britain it is taken every ten years.

How is it taken?

It is taken rapidly and simultaneously, by means of schedules distributed all over the country, and these are all filled up on a fixed date previously determined upon.

What Information does the Census give?

Besides the actual number of the population, it gives the name, age, sex, rank or profession, and condition of every person, and the relation they bear to the head of the family. It also gives the number of inhabited and uninhabited houses, and enables us to group the population according to age, sex, etc.

Whether are Males or Females more numerous?

Females: in England and Wales alone the excess is close on a million.

To what is the Increase of Population due?

The INCREASE depends chiefly on the birth and death rates: emigration and immigration affect it but very little.

What is the "Natural Increment" of the People?

It is the excess of births over deaths. The "actual increment" can only be determined by enumeration.

How is Population estimated by Logarithms?

The population at the most recent census and the one before are taken, and by consulting the logarithm tables

the eorresponding logarithms of these are found. By subtraeting the logarithm of the seeond figure from that of the first, the logarithm of *deeennial* inerease is obtained. The logarithm of annual inerease may be obtained from this by dividing by 10.

How is Estimate made from the Number of Inhabited Houses ?

By multiplying the number of houses (aseertained from the assessment roll) by the average number of persons per house as ascertained at the last eensus. The fallaey here is that the numbers of persons may and do alter with different houses.

From the Birth Rate ?

It is a question of simple proportion, granted the number of births in any year, and the birth-rate of the previous eensus are known. For example, if the number of births be 2454, and the birth-rate at last eensus be 30·8, to estimate the population state thus :

$$30{\cdot}8 : 2454 : : 1000 \text{ or } \frac{2454 \times 1000}{30{\cdot}8} = 79{,}675.$$

How is the Population estimated during the Ten Years between one Census and the next ?

We must first find the "estimate of population." One plan is to assume that the rate of inerease between the past eensus and the next will be the same as the rate of inerease between the last eensus and the previous one. That plan is faulty, however, beeause eaeh year inereasing numbers reaeh a marriageable age, beeome parents, and add to the population. The inerease is therefore in geometrieal proportion. Beeause the Registrar General's method by logarithms takes this into aeeount its value and trustworthiness is increased. This method is not

absolutely reliable in new and rapidly increasing districts; in this case we must find the number of the houses in the district and the average number in each. In finding the estimated population, take into account—

1. The excess of births over deaths.
2. The amount of emigration.
3. The amount of immigration.
4. The marriage registration.

Give a detailed Example.

Suppose it is desired at the beginning of 1905 to estimate the population of Leith. From the Registrar General's Report the population of 1891 must be found, viz. 68,705; also the population at 1901, viz. 76,667. From the logarithm table it is found that the log. of 68,705 is 4·8369378, and that of 76,667, 4·8846085. Subtracting one from the other, the figure 0·0476707 is obtained, that being the log. of decennial increase. This divided by 10 gives ·00476707, the log. of annual increase. The estimation is to be made for 1905, which is four years after the taking of the census, and the log. of increase will be four times the annual increase:

·00476707 × 4 = ·01906828 = log. of increase for four years.

As the *mean* population of 1905 is desired, the log. of a quarter's increase, or ·00119176, has to be added. The log. of increase to the middle of 1905 is therefore ·01906828 + ·00119176 = ·02026004, and to obtain the log. of the mean population of 1905 it is only necessary to add this increase to the log. of the census population of 1901, thus:

4·8846985
·0202600
4·9049585

The result is the log. of the population of 1905, and a second reference to the tables gives us the corresponding figure of ·9049585, 80,345, which is the mean population of the burgh in 1905.

In registration the CAUSE OF DEATH is the most important factor, and this may either be primary or secondary, thus—

In Enteric Fever death is often	from Pneumonia.
In Scarlet Fever	from Nephritis.
In Measles and Whooping-Cough	from Bronchitis.
Phthisis	from Diarrhœa.
Rheumatic Fever	from Endocarditis.

What Circumstances will affect the Mortality Statistics?

1. Fluctuations of populations.
2. Prosperous or adverse times.
3. Peace or war.
4. State of the weather.
5. Improved sanitary arrangements.
6. Epidemics.

What are the Sources of Information?

The Registrar General's Reports; and for any special district, the books of the District Registrar and those of the Board of Guardians.

What Points should the Health Officer's Weekly Report include?

I. THE BIRTH-RATE—

1. Live-born.
2. Still-born.

II. The Marriage-rate.

III. Total Death-rate—

1. Death-rate at different ages—
   (1) In infaney—
      (*a*) First week.
      (*b*) First year.
   (2) In adults.
2. Death-rate from zymotie diseases.
3. Classified death-rate from other eauses.
4. Degree of healthiness or unhealthiness of the distriet—
   (1) Number of persons eonstantly sick, arranged aecording to age, sex, oeeupation and disease.
   (2) Average duration of illness.

What is the Rate of Mortality?

The number of deaths within any given area.

What is meant by "Expectation of Life" or "After Life Time"?

The probability of the age any one person of a given population will attain, aecording to the rate of mortality found to prevail within that area, regard being had to the age of the party at the time of fixing the expeetation.

How is it Calculated?

Willich's formula is to take two-thirds of 80, *minus* the age of the person. Thus at tweuty the expeetation of life is 80 − 20 = 60, and two-thirds of 60 is = 40—*i.e.* the person will in all probability live for forty years.

What is the Standard Death-rate ?

It is the death-rate at all ages calculated on the assumption that the rates in each sex at each of the age groups were the same as in the whole country during the previous intercensal period.

What is the Corrected Death-rate ?

It is the death-rate which would have occurred had its age and sex distribution been the same as that of the country as a whole. The standard death of the whole country, divided by the standard death-rate of the town, gives the amount of the ratio on what is called the *factor for correction.*

What is the Comparative Mortality Figure ?

This compares the corrected death-rate of the town with the recorded death-rate of the whole country in the year under consideration.

What is the Object of Poisson's Formula ?

It is frequently employed to determine the liability to error in vital statistics, because too much reliance may now and again be attached to averages, especially when too few numbers are taken into account for arriving at averages.

What are the Common Causes of Death among Infants ?

Debility, inanition and prematurity, diarrhœa, dysentery, measles, whooping-cough, accidents such as "overlying," bronchitis and pneumonia. Of the total infantile mortality 70 per cent. are due to the aforementioned causes.

Among illegitimate children the death-rate is double that of legitimates.

What is the Recorded Death-rate?

It is the crude death-rate after allowance has been made for deaths occurring in hospitals, institutions, etc.

What is meant by the Mean Age at Death of a Population?

It may be obtained by adding together the ages at which people die, and dividing the number of years by the number of deaths. It is no indication of the health or sanitary condition of a community, but gives the average ages at death of populations.

What is a Life Table?

It is a *biometer* and represents "a generation of individuals passing through time." It measures the probabilities of life and death of this generation at birth, and of the survivors at each successive age period, until the whole generation is extinct.

What are the Data required for constructing a Life Table?

It is necessary to possess particulars from a census return of the number, age and sex distribution of a population, and a return of deaths for one or more years among the same population, grouped in the age periods as employed in making up the census.

What is the Law of Population Increase?

Population, when unchecked, goes on doubling itself every twenty-five years, or tends to increase in a geometrical ratio—*i.e.* 1, 2, 4, 8, 16, 32, etc.; hence, the larger the population the more rapidly, apparently, does it increase.

What Points should be contained in a Death Certificate?

1. Place.
2. Date.
3. Age.
4. Sex.
5. Employment.
6. Cause of death, and whether primary or secondary or both.

What is the Normal Death-rate?

About 11 per 1000; but in a town 17 per 1000 indicates a very healthy condition, and may be taken as a very fair standard.

What is meant by "Climaterics"?

It is a popular belief that the years of human life, produced by multiplying 7 into the odd numbers, 1, 3, 5, 7, 9, are climateric; and the last is the "grand climateric" for men—*i.e.* 63; and the one before that the grand climateric for women—*i.e.* 49.

What is meant by the Death-rate or Death-toll?

The yearly amount of mortality in the population, expressed as the number of deaths occurring annually in every 1000 of the population.

From what Data is it ascertained?

From the Registrar General's Annual Report of the Mortality of the United Kingdom, but this only gives the country taken as a whole. For any given district it must be taken from the actual or estimated population, and by consulting the books of the District Registrar and the books of the Board of Guardians.

What Causes raise the Death-rate in Towns ?

1. Over-crowding. The death-rate is high in direct proportion to crowding.

2. Want of fresh air and pure water.

3. Insufficient accommodation and bad drainage.

4. Profligate and intemperate habits.

5. Accidents.

6. In London and other large towns many die in the hospitals who ought to be accredited to the country. The death-rate of many watering-places is high because of the numbers who go for the benefit of health, but only to die.

What is the Birth-rate ?

It is the total births per year, divided into the rate per 1000 of the population living in the district at all ages.

Are Boys or Girls more numerous at Birth ?

The male births are most numerous. In England and Wales the excess of boys is smaller than anywhere else; and it is greatest in Italy.

How does Place affect the Birth-rate ?

In urban districts the birth-rate is high, because the marriage-rate is high, and the women are necessarily younger than in country districts; also, there is a high rate of infant mortality, and this shortens the intervals of child-bearing.

In fashionable towns where there is a large number of unmarried servants employed, the birth-rate is always low.

What is the Relation between the Birth-rate and the Death-rate?

Where the birth-rate is high, so also is the death-rate for that special town, because so many children die in infancy.

Does the Total Death-rate of a Country represent the Actual Death-rate of any given District?

No; the total annual death-rate does not represent the actual death-rate in small sanitary districts. In estimating the actual death-rate, corrections must be made for persons not belonging to the district, as in hospitals, workhouses, asylums, and for visitors, and also for deaths of persons belonging to it but dying outside the district: the death-rate of the division where the workhouse is will be higher than it REALLY is, unless a correction be made as to the residence of those dying in it; and the death-rate of the surrounding district will appear smaller than it really is, unless indoor paupers belonging to it be counted: hence the importance of ascertaining the exact residence of those dying.

What is meant by "Infant Mortality"?

The total number of deaths under one year, compared with the births, registered and expressed as so many per 1000.

Give the Rate of Mortality at various Ages.

First year—17 per cent. die.

Under five years—50 per cent. die.

From this to puberty the rate of mortality declines, and then SLOWLY increases up to fifty or sixty years: from this to the end it increases at such a rate that it is doubled every ten years.

How does Locality affect the Death-rate ?

It is high in towns and low in the country: in towns it varies at different parts—in fact it increases in proportion to the density of the population. In fashionable suburbs, where there is a large excess of adults of the ages in which a low death-rate prevails, and where the birth-rate is also low, the death-rate is usually very low. In poor and crowded places, where no servants are kept, and where the birth-rate is high, the death-rate is usually very high for reasons already explained.

How does Season affect the Death-rate ?

Winter predisposes to diseases of the respiratory organs, especially if the temperature be very low; summer predisposes to intestinal disorders, and more especially if the temperature be very high: the high temperature increases the sick and death rate from diarrhœa and filth diseases. The death-rate is highest during the first quarter of the year and lowest during the third quarter.

What does Longevity embrace ?

It embraces—

1. The mean age at death.
2. The "expectation of life" or the "mean after life time" at various ages.

How do you find the Mean Age at Death ?

Divide the sum total of the ages at death by the number of deaths. It varies according to the proportion of young and old; if the birth-rate be high, the "mean

age" will be low because of the high infant mortality. The mean age at death is—

In England . .	40 years.
In France . .	34 years.
In Sweden . .	31 years.

What are the Periods of Life?

First dependent period,	from 0 to 20 years.
Useful or productive period,	from 20 to 60 years.
Second dependent period,	from 60 onwards.

What Effect has Sanitation on these Periods?

It has chiefly increased the useful or productive period.

What is meant by Morbidity?

It means the "sick-rate," or the amount of illness in a community: for every death there are two years of severe sickness.

In judging of the Death-rate, what Points should be considered?

1. It may be due to a preponderance of adult and selected lives, while the sanitary condition is by no means good.

2. It may not be above the average all over, while at some parts it is excessively high.

3. A good sanitary condition is shown by the low death-rate from INFECTIOUS diseases, fever, diarrhœa and phthisis; and amongst children under five years from all causes.

4. Also consider the social causes, as intemperance, immorality, early and injudicious marriages.

What is a "Legal Infant"?

Any person under twenty-one years of age.

Give some Examples of the Effect of Occupations on the Death-rate.

Stone-masons, lapidaries, knife-grinders, especially "dry" grinding pin-pointers, buttonmakers, pottery workers, and flax-hacklers, suffer much from lung affections, and very often die young.

DWELLINGS

What are the Advantages and Disadvantages of Porous Soils as Sites for Buildings?

They are the driest (gravels and sands), but owing to their porosity they can be readily polluted by leaking drains, cesspools and surface accumulations of filth.

What is "Ground Moisture" as compared with "Ground Water"?

When there is air as well as moisture between the interstices of the soil, one speaks of "ground moisture"; when, however, the interspaces are completely filled with moisture "ground water" is implied.

Why do the Levels of Ground Water vary?

After heavy rainfall the ground water level rises; the periodic rise takes place during late autumn, due to the increased percolation of rain water during autumn and winter. During the drier months of the year the level of the ground water shrinks.

What Influence do these Variations exert?

They affect the movements of the ground air. Ground air may also be affected by barometrie influenees, variations in temperature, and the perflating aetion of wind.

What Influence may a House have upon Ground Air?

The warm interior of a house may aspirate the air out of the soil. Thus it becomes necessary to cover the site on which a house is built with an impervious layer sueh as asphalte or eement eonerete. This area is known as the "solum" of the house.

What are the Evidences of the Impurity of Ground Air?

Its diminution in oxygen and its excess in carbonic acid. Leaking drains, cesspools, etc., will pollute the ground air, as will cemeteries and graveyards. Made soils—made up of refuse dumped from houses—also affect ground air.

What is the probable Explanation of Pettenkofer's Theory regarding the Association of Enteric with Ground Water?

His observations showed that with the sudden fall of levels of ground water after an unusually high level enteric fever inereased in prevalence. This is believed to have been caused by the pollution of shallow wells during excessive rain. Though the outbreaks occurred when the levels of the wells were low, possibly pollution had taken place two to three weeks previously when the levels were unusually high.

What Disease is specially associated with Wet Subsoil in Towns—e.g. Damp Rooms or Floors?

In towns on wet subsoil there is much phthisis, and the wetter the worse; in towns standing on dry subsoil, there is less phthisis.

Give Examples of this.

After draining the subsoil the death-rate from phthisis fell—

49 per cent. at Salisbury.
47 per cent. at Ely.
43 per cent. at Rugby.

What Effect has Drainage of the Soil upon the Temperature?

The temperature of drained land is raised from $1\frac{1}{2}°$ to 3°, which is equivalent to being transported 100 to 150 miles southwards.

Explain this Effect.

The rain falls and fills the soil, and as there are no subsoil drains, there is no escape for it, but it is imprisoned in the soil, and evaporates from this. Take 30 inches of rain on every acre per year, and the daily weight of water evaporated is equal to $8\frac{1}{4}$ tons. But watery vapour is just steam, and in transforming water into steam 536 thermal units are rendered "latent": in other words, the heat necessary to vaporise $8\frac{1}{4}$ tons of water would correspond to 24 cwts. of coal in a steam boiler; every grain of water requires heat enough to raise 960 grains 1° Fahr. Now this large amount of heat must come from somewhere, and it comes from the soil and the atmosphere round about the wet land. The water evaporated is proportional to the surface exposed; and hence is much greater from porous substances kept wet—*e.g.* the porous soil—THAN FROM THE SURFACE OF WATER ITSELF.

Give the Aspect and Shelter of the Site of Dwellings, and the State of the Soil under and around.

The ASPECT—south-east. It should be SHELTERED from the east and north-east winds. The soil under and

around should be dry, and if not naturally so it should be drained.

What is the Effect of Clay Subsoil?

Clay subsoils give off vapour slowly, but in the end give off more than free soils; hence, they are "cold" and form very bad sites. "Water-logged" soils are bad, until the subsoil water is lowered by drainage, not only to prevent evaporation, but also to prevent the rise of water by "capillary attraction" to the cellar floors and foundations.

Is the Side of a River a Good Site?

No; not unless it is well drained.

How does the Mode of Drainage differ in different Subsoils?

If the soil is "free" a single drain will do for a wide area, and drains should be as far from the building as possible, lest they carry off sand, etc., and lead to "settlements" of the walls of the house. In stiff clay soils the greater the number of drains the better. Protect the drains from roots of trees. Avoid if possible placing them under the building, and protect from the pressure of the walls if it is necessary for drains to pass under walls.

How is the Water prevented from rising by Capillary Attraction?

To prevent the water rising in the walls and floors, lay a bed of asphalte or concrete six inches deep all over the base of the dwelling, the walls on a foundation of concrete. Provide "damp proof courses"—impervious cement and slate or asphalte—glazed perforated bricks with hollow walls. If the basement floor is below the level of the natural surface of the ground, there should be an area between it and the house wall.

Would this Plan be good in Clay Subsoils ?

No; in clay soils there should be no basements or cellars, because they would always be damp, and therefore cold, clay being so retentive. In this case the foundations should be raised above the level of the clay, with free ventilation between the surface and the floor of the dwelling.

What is the Cause of "Dry Rot" ?

It is due to the growth of a fungus fostered by damp, darkness and lack of ventilation.

Are old Sites or Rubbish Heaps good Sites ?

They must not be built upon for at least two or three years.

What Diseases result from Dampness ?

Rheumatism, phthisis and bronchitis.

What Points should be attended to in Hot Water Apparatus ?

1. The boiler should be of wrought-iron, properly tested before use.

2. It should be inspected occasionally, and if necessary cleaned.

3. Its pipes should be carried up within the building, and not against an external wall.

4. Its cisterns should be placed in a position easy of access, and well protected from frost.

5. Its safety valve should be easily adjusted, sensitive, and placed in an easily accessible position to be taken to pieces and refixed. Use valve of 135 lbs. to square inch, or 9 atmospheres.

If there is no boiler, but merely a coil of pipes, as in Perkin's method, it is necessary to use an "expansion

pipe" at the highest point of the apparatus, as water in being heated from the freezing to the boiling point expands one twenty-third of its bulk; in filling the pipes, leave the expansion pipe empty.

How may a Boiler be accidentally burst?

If the inlet and outlet pipes be frozen and the fire under the boiler ignited any water left in the boiler would be quickly converted into steam; this, being unable to find escape, might burst the boiler. On the other hand, should the water be boiled away, a sudden inrush of water would lead to serious accident.

What Relation has the Subsoil Water to Phthisis, Enteric Fever and Cholera?

Any kind of wet subsoil fosters phthisis, whatever the level of the water may be or its variation in level from time to time; the strata may either be retentive of wet, or they may be flat, so that they become "water-logged."

Any great or sudden change in the level of the subsoil water, plus or minus, may be followed by epidemics of enteric fever. The cholera in India is coincident with low level of the subsoil water. This shows the great danger of leaky sewers in the presence of subsoil water. Subsoil water is always on the move towards the sea or rivers, and ready to carry pollution with it; in sloping ground disease due to excremental pollution occurs only at the lowest part. Excremental pollution also affects the "ground air," and the hot air and lessened pressure in houses tends to "draw up" this pollution. It follows from this that sewers should be perfectly water and air tight.

Should Sewers act as Subsoil Drains?

No, not in ordinary cases; if it be possible to maintain a constant flow into the sewer from the subsoil, as in

swampy districts, it may be admitted directly into the sewers.

State what you know about Variations of Temperature under different Conditions?

The equator and 80° F. = Torrid.
80° to 60° - - = Hot.
60° to 40° - - = Temperate.
40° to 24° - - = Cold.
Still colder - - = Polar.

The temperature lessens 1° F. for every 300 feet above the earth's surface, and from the equator to the poles it lessens 9° F. for every 10° latitude. The proximity of the ocean also lowers the temperature. Mountain ranges deprive the winds of moisture and allow of more radiation from the ground, as well as increased evaporation, and hence it becomes very cold. Over declivities and rising grounds the air becomes cooled, and flows down into the valleys, and forms lakes of cold air.

What is the Special Danger in Hot and Torrid Countries?

In torrid and hot countries the danger is due to the heat and moisture which favour decomposition of animal and vegetable matters.

What is the Temperature of the Soil?

The daily change does not extend more than 3 feet down and never below 40 feet, and the change at 24 feet is extremely small. As we pass down the temperature increases 1° F. for every 55 feet, or say on an average 1 in 50.

What is the Effect of Snow?

Snow is a bad conductor, and prevents the passage of heat from the soil to the air during the winter months.

Is the Soil a good Heat Conductor ?

It varies; loam, clay, and rocks are better conductors than sand, and therefore do not become so hot as sand does: sand becomes the hottest of all soils on the surface, and humus the least.

What is the Effect of Herbage ?

It lessens the amount of heat absorbed, because of the constant evaporation, that carries so much of the heat away with it.

What is the Effect of Trees ?

Changes of temperature take place slowly among trees; they make the nights warmer and the days cooler. Vegetation makes the distribution of heat over the twenty-four hours more equal. Forests lessen evaporation, but increase humidity, because the woods cannot carry it off; they keep the summer temperature lower and the winter higher—they thus act like mountains or the sea.

What is the Average Rainfall ?

In England it is 32 inches.

How does it vary ?

On the West Coast of Great Britain and Ireland it is much greater, and varies from 75 to 150 inches. On the East Coast of the same parts it is very much less, varying from 20 to 28 inches. It is increased also by the proximity of the sea, hills and forests. In making calculations always take the maximum and minimum rainfalls, and do not trust to the average.

What becomes of the Rain?

About two-thirds are lost by evaporation; plants and animals use it up; a good deal sinks into the soil and passes to rivers, the sea, and then evaporates for rain, dew, etc. On this the moisture and ground water of the soil depends.

Forests and turf retain the moisture, and protect the soil and precipitate the rain from clouds; they thus have a very important bearing on the water supply. Vegetation also causes much evaporation. Capillary attraction rises highest in chalk, and less in sand.

What is the Effect of Drainage on Temperature?

It raises the temperature of fields 6° or 7° F., because the evaporation is less and the percolation greater. Every cubic foot of water evaporated lowers the temperature of 3,000,000 cubic feet of air 1° F.

How does the "Ground Air" vary?

It depends on the level of the ground water, and moves in and out according to the barometric pressure and wind. If there is much water the air carries vapour with it, and the site therefore is cold and damp. Ground ought to be free from water, and also from organic impurities. By-and-by of course it becomes oxidised into harmless products; but this produces carbonic acid, which is then carried up with the ground air into the houses—the "ground air" sometimes contains as much as 50 per cent. of carbonic acid. Substances decay much more quickly in open, loose soil.

How does the Ground Water affect the Healthiness of Sites?

Low subsoil water, say 15 feet down, is healthy; high, say 5 feet down, is not healthy. A fluctuating level is

specially bad. Keep the level low, therefore, if possible by proper drains; and if it cannot be kept low, at least keep it at one level.

How can a Damp Subsoil be detected?

Fogs appear soon over moist soil; also the vegetation is greenest, and midges collect over moist places.

How do Plants affect Healthiness?

They increase the moisture, and at night evolve carbonic acid gas, and during the day also, if the sun is not shining. Decayed and fallen leaves, therefore, should always be quickly removed.

How do Local Conditions affect the Sites?

All sites are bad, if filthy; to turn up soil impregnated with decaying organic matters is bad, until the matters are entirely oxidised. Clayey soils are cold and damp, because of the little percolation, and hence predispose to rheumatism and catarrhs: sand and gravel are good in this country, if kept free from organic matters and water. In hot countries they are bad, because they become so hot, unless they are covered with grass. The air over clay soils is moist, but the soil is less easily polluted by sewage, as it cannot sink in.

How does Soil affect the Death-rate?

The fever-rate is highest on alluvial clay soils and "water logged" ground; the general death-rate is highest on porous wet soils.

Is an Elevated Site good?

Elevation is usually good, unless the wind blows over marshes and malarial ground—*e.g.* a town on sloping

ground immediately above a marshy plain and with a mountain range behind, is very bad, and the mortality is sure to be very great.

Give a short Summary of the Points to be attended to in seeuring a Healthy Site.

1. Avoid clay soils.

2. Avoid the foot of a slope, or deep valleys that receive drainage from higher levels.

3. Avoid high positions exposed to winds blowing over marshy ground, as this would predispose to fevers.

4. Elevated sites on the margin, or at the heads of steep ravines are not, as a rule, good.

5. Rank vegetation is unhealthy, because of so much decomposing matters in the soil, and also beeause the ground is moist below.

6. In warm climates, muddy sea beaches or river banks subject to periodic floodings, or marsh land with braekish water are very bad.

7. But a porous subsoil, not too much vegetation, a good fall for drainage, not receiving or retaining the water from the higher ground, and the prevailing winds not blowing over marshy land, forms a good site.

What are Pettenkofer's Views as to the Cause of Typhoid Fever?

He believes that the conditions necessary for typhoid fever are :—

1. Unusual height of the ground water, followed by a rapid sinking.

2. Impurity of the soil from animal impregnation.

3. Heat of the soil.

4. Presenee of a specifie micro-organism or germ.

As already shown, when the ground water sinks air is

drawn into the soil, and when it rises the air is forced out again more or less impure; the heat and moisture favour decomposition. Pettenkofer holds the same views with regard to cholera.

METEOROLOGY

What is meant by "Climate"?

It embraces all those physical influences connected with the soil, heat of the atmosphere, or water of a place, which act and react on man and more or less materially affect his wellbeing.

What is meant by "Meteorology"?

It is that department of natural philosophy which treats of the phenomena of the atmosphere that relate to weather and climate, or the laws to which they are subject.

How is Climate divided?

Into continental, insular and mixed.

Explain these Terms?

1. A CONTINENTAL climate consists of a very cold winter and a very hot summer—*e.g.* Asia.

2. An INSULAR climate is characterised by a cool summer and a mild winter—*e.g.* Europe.

3. A MIXED climate is one inclined to be continental in winter and insular in summer—*e.g.* North America.

What Purpose is served by the Moisture of the Atmosphere?

Tyndall has shown that the vapour of water exerts extraordinary energy as an absorbent of heat; and has shown that, as a consequence of these facts, the watery

vapour suspended in the air serves as a covering or protection to the earth, shielding it from the sun's heat by day and from the chilling effects of its own radiations by night.

How can Storms be predicted?

In Europe stormy weather is accompanied by a DIMINUTION OF ATMOSPHERIC PRESSURE. The existence of this diminished pressure is made known by the fall of the barometer, while the maximum depression is still a considerable distance out in the Atlantic Ocean. Collateral information pointing to an advancing storm may be obtained from the direction of the WIND and the CIRRUS cloud.

What Country is specially well situated for giving Storm Warnings?

The United States of America: when the storm appears in the Western States, bordering on the Rocky Mountains, a message of warning is sent to the Central Office in Washington; in this case the prophecy is sure to be correct, as the storm is actually seen advancing.

How is the Atmospheric Pressure measured?

By the barometer.

What Height of Mercury does the Atmosphere support?

About 30 inches, or 760 millimetres, at the level of the sea.

What is the Pressure of the Atmosphere?

Fifteen pounds to the square inch.

What is the Height of a Column of Air supporting Thirty Inches of Mercury?

The heights of the columns of two fluids in equilibrium are inversely as their specific gravities; and as air is 10,784 times lighter than mercury, the height of the atmosphere would be 10,784 times 30 inches, or about 5 miles, if it were composed of layers of equal density throughout.

What is the Probable Height of the Atmosphere?

Probably from 50 to 60 miles, as from its elasticity and lessened pressure it becomes less and less dense as we ascend; it may even extend to 200 or 300 miles, though at 50 miles it is so rare that the effect on the twilight is nearly inappreciable.

Could a Water Barometer be used?

Yes, it may be used; but there are several serious objections—

1. As water is nearly fourteen times lighter than mercury, we would require a barometric column of water of about 35 feet long.

2. The space in the tube above the water is far from being a true vacuum, but is filled with watery vapour, and this presses upon and depresses the water column, with a force varying with the temperature: at 32° it is depressed half-an-inch, and at 75° it is depressed a foot.

The advantage of a water barometer is that it shows changes of atmospheric pressure on a large scale.

How is the Mercury prepared?

It must be boiled in the tube to expel all the air and moisture, and it must also be perfectly pure, otherwise it will stick to the tube and impede its movements. When

pure and free from air, when the tube is inclined the mercury will give a sharp metallic click against the top of the tube.

What are the Varieties of Barometers?

1. Cistern barometers—the best form.
2. Siphon barometers.

To what Errors is the Cistern form liable?

1. Error of capillarity.
2. Error of capacity.

What is the Error of Capillarity?

The mercury is depressed in the tube a little below the true level, and the smaller the tube the greater is this depression: this is due to capillarity and takes place with all liquids that DO NOT WET the glass; the upper surface of the mercury too is convex.

What is the Error of Capacity?

It is due to the varying height of the mercury in the cistern, as the barometer falls the mercury rises in the cistern, and *vice versa*; but the height of the barometer is the distance between the surface of the mercury in the cistern and the upper surface of the mercury in the tube, and when the one falls the other rises and *vice versa*, so that sometimes the reading is too high, and again at other times it is too low.

How is it corrected?

By making the cistern as large as possible to REDUCE the error, or by having a movable bottom to the cistern, that can be raised or depressed with a screw, so that before

reading the barometer the level of mercury in the cistern is always set to zero—the point from which the instrument was graduated.

Has the Siphon Barometer these Disadvantages?

No; it has neither the one nor the other.

Then why is it not the best?

1. It is necessary always to take two observations—to read the level at both ends of the tube, and this often results in mistakes.

2. The open end allows impurities to enter and spoil the mercury.

Mention other Kinds of Barometers.

The wheel barometer or weather glass, and the Fitzroy barometer—both forms of the siphon barometer.

What is the Aneroid Barometer?

The principle depends on the varying pressure of the atmosphere upon an elastic metallic chamber partially exhausted of air, and then by a series of levers a pointer is made to travel over a graduated dial.

Are these to be trusted?

No, not for long; they are not so exact as the mercurial barometers, though they are portable and not liable to be broken, and are therefore useful for nautical purposes and for measuring heights.

What is a Vernier?

It is an instrument for reading off the graduated scale of the barometer, true to the $\frac{1}{100}$ or $\frac{1}{500}$ part of an inch: it is named after its inventor—Peter Vernier.

Explain its Construction and Mode of Use.

It consists of a piece similar to the barometer scale, along which it slides, but 10 divisions of the Vernier are =11 divisions of the scale—*i.e.* to $1\frac{1}{10}$ of an inch: hence each division of the Vernier is = the $\frac{1}{10}$ of an inch + the $\frac{1}{10}$ of a $\frac{1}{10}$ or $\frac{1}{100}$, or to $\frac{10}{100}$ and $\frac{1}{100}$—*i.e.* in all $\frac{11}{100}$; so that two divisions are equal to $\frac{22}{100}$ of an inch or 0·22, also three = 0·33, and so on.

To use it: let the mercury stand between 29 and 30 inches. The Vernier is set so that its zero line forms a tangent to the convex curve of the mercury in the column. As this is between 29 and 30, put down 29 as the first figure, next count the tenths from 29 upward, and let the Vernier indicate more than $\frac{7}{10}$, but less than $\frac{8}{10}$, and write 0·7, next find the point at which a division of the scale of the Vernier and that of the barometer lie in the same straight line, say at figure 6 of the Vernier, and this therefore is = 0·06, so the whole reading is 29·76 inches.

How is Temperature measured?

By the thermometer: a closed glass tube with a bulb at one end and filled with mercury or spirits of wine.

Are both equally useful?

No; mercury is the better, owing to its uniform expansion by heat, the readiness with which it indicates changes of temperature, and the great range of its fluidity, but as it freezes at −37·9° F. a spirit thermometer must be used to register the greatest cold.

What are the Varieties of Thermometers?

1. Fahrenheit—with the freezing point at 32° and the boiling point at 212°: the space between, therefore, being

divided into 180 equal parts. This form is in eommon use in England and America.

2. Centigrade (Celsius)—the freezing point is zero and the boiling point 100° : the seale is therefore divided into 100 equal parts, and hence its name. It is used in France and most Continental eountries, and for seientifie purposes.

3. Reaumur's—freezing point zero, and the boiling point 80° : the scale is thus divided into 80 equal parts. It is used in Germany and Russia.

How would you convert Fahrenheit into Centigrade, and vice versa ?

F. to C.—first subtract 32°, then multiply by 5 and divide by 9.

C. to F.—multiply by 9, divide by 5, and add 32°, because 32° on the Fahrenheit scale is the zero of the Centigrade scale.

What is meant by Maximum and Minimum Thermometers ?

Thermometers for recording the highest and the lowest temperature during the twenty-four hours; they are self-registering: mercury is used for the one, and spirits of wine for the other. The former reeords the highest temperature that oecurs during the day; the latter the lowest temperature that oeeurs during the night.

What Points are to be attended to in placing Thermometers ?

They should be protected from the direet and reflected rays of the sun, and at the same time have a free eirculation of air around them.

How is this best done?

By using Stevenson's Louvre Boarded Box: the box is painted white, as this colour absorbs least of the sun's rays.

At what Height should it be placed?

It is set on four posts of such a height that when the minimum thermometer is hung in its place, it is exactly 4 feet from the ground.

What Position should the Box occupy?

It should be placed at some distance from walls or other objects, in an open space, and over old grass to which the sun has free access during most of the day.

Where should it not be placed?

It should not be placed on the north side of walls or buildings; nor over black soil—*i.e.* not covered with grass.

Why?

The wall acts as a cooler during the day and during summer, and as a source of heat during the night and during winter; hence we do not get a sufficiently high day or summer temperature, nor a sufficiently low night or winter temperature, so that the daily range of thermometers so placed is always small. If the box is placed over black soil, which is more highly heated during the day, and cooled to a greater degree at night than grass, the maximum temperature will be too high and the minimum too low.

How should the Instruments be read?

Open the lid of the box, do not touch the instruments, and first read the dry and wet bulbs of the hygrometer,

so that THEY may not be affected by the heat of the person standing near.

Then read the minimum, by noting the degree on the scale at which the end of the index farthest from the bulb is lying.

Next read the maximum by noting the degree on the scale at which the end of the index nearest the bulb is lying (in Rutherford's); for the others, read the upper level of the mercurial column. Then set the maximum and minimum thermometers, and close the box.

What are the Best Hours for Observation?

For two observations—9 A.M. and 9 P.M.

For four observations—3 A.M., 9 A.M., 3 P.M. and 9 P.M.

How does Interchange of Temperature among Bodies take place?

By conduction, convection, and radiation.

What is meant by "Conduction"?

The communication of heat from particle to particle; and it implies close contact with, or very near approach to, a hotter body.

Give Examples.

1. Place a poker in the fire, by-and-by the other end will become hot.

2. The propagation of changes of temperature downwards through the earth's crust.

Why does Damp Air feel colder than Dry Air of the same Temperature?

Because damp air is a much better conductor of heat, and conveys away the heat from our bodies more rapidly than dry air, and hence the sense of cold.

Why does a Lump of Marble feel colder to the Hand than a Mass of Wool at the same Temperature?

For the same reason; marble is a better conductor of heat and conveys away the heat from the hand much faster than the wool does, hence the feeling of greater cold.

Is Snow a good Conductor?

No; it is one of the worst.

How is this?

Because it is composed of crystals that have a large quantity of air entangled among their interstices, just as loose porous soils full of air are bad conductors.

How does Snow protect the Soil?

1. It prevents the escape of heat from the earth to the air.

2. It sets a limit to the depth to which severe frosts penetrate, thus protecting the roots of the plants.

What is "Convection"?

The process by which fluids and gases are heated by circulation of their particles carrying the heat with them.

Give Examples.

The heating of water in a boiler; when heat is applied to the bottom of the vessel the particles of water at the bottom are heated and rendered lighter, and therefore rise to the surface, while the colder and heavier particles descend.

It is also seen in the winds and in the currents of the ocean; when the surface is heated by the sun, the

air resting on that surface is heated, becomes lighter, and ascends, and colder air passes down to take its place. Under the tropics the air becomes highly heated, and ascends and flows off towards the poles, while cold currents flow towards the equator.

What Benefits arise directly from this ?

It secures a more equable distribution of temperature over the globe, thus mitigating the cold of the polar regions, and moderating the severe heat of the tropics.

What is Radiant Heat ?

It is heat given out in rays from hotter bodies to colder ones, and is constantly going on among bodies freely exposed to each other, and tending to bring all bodies to the same temperature.

Give Examples.

The heat derived from an ordinary fire, and felt though we stand at some distance from it.

What is the Course of the Rays ?

They proceed in straight lines in all directions from their source, and are not diverted from their straight course by winds; the intensity is proportional to the temperature of the source, and inversely as the square of the distance from the source.

What is "Solar Radiation" ?

When the surface of the earth is turned towards the sun it receives more heat than is radiated from it (the earth); the heat is radiated from the sun, and absorbed by the earth, into which it passed by conduction.

How does this affect the Temperature of the Air ?

Badly conducting surfaces raise the temperature of the air over the soil most; hence, a dry sandy soil, devoid of vegetation, has the greatest effect—*e.g.* the sandy deserts of the tropics. Loam, clay and rock are not heated so high as sand, and vegetation also protects from the direct rays of the sun; and, besides, much heat is conveyed away by evaporation of water from the pores of plants. Vegetation, therefore, causes a more equal distribution of heat over the twenty-four hours, lessening the cold of night and the heat of the day.

What Influence do Forests exert on Climate ?

Trees store up the heat of the day against the cold of the night; changes of temperature take place very slowly among trees; they thus make the nights warmer and the days colder, giving the climate an INSULAR character. Forests also keep the summer temperature lower, and maintain the winter temperature higher than it would otherwise be.

How do Forests increase the Rainfall ?

In a large forest the temperature is lower than the surrounding district and affects the rain-bringing winds in the same way as a low range of hills—*i.e.* it cools the wind, and so much therefore of the watery vapour it held in suspension is thrown down as rain.

What is meant by the "Specific Heat" of a Substance ?

The number of units of heat that are required to raise the temperature of one pound of it by one degree.

What is the Specific Heat of Water ?

Of all known substances it has the greatest specific heat: for example the amount of heat necessary to raise

one pound of water 1° will raise one pound of mercury 33°; as compared too with the soil and the rocks of the earth's crust, water is in the proportion of about 4 to 1.

What is the Natural Consequence of this?

The surface of the sea cannot be raised to nearly the same degree of heat by the sun's rays as the surface of the land, and when the temperature is falling the sea cools much more slowly than the land. The surface of the land may be as high as 140°, but the surface of the sea rarely ever exceeds 85°.

Name another Result of this Fact?

It is the cause of land and sea breezes, as the land is much more heated, and cools much more rapidly than the sea. In the morning a breeze sets in from the sea, very gently at first, and increases to a stiff breeze in the heat of the day, and again sinks to a calm towards evening; after this a breeze begins to blow off the land during the night and dies away in the morning. It is due to the general fact that the wind blows from a region of higher to one of lower pressure; now the land is heated to a much greater degree than the sea during the day, by which the air resting on it, being also heated, ascends, and the cooler air of the sea breeze flows in to supply its place; but during the night the temperature of the land falls below that of the sea and the colder and denser land air flows away over the sea as a land breeze.

How is the Surface Temperature of the Land measured?

By a maximum black-bulb thermometer, in an ordinary maximum thermometer having its bulb covered with a thin coating of lamp black.

How is it placed?

It should be placed horizontally over short grass, so near the ground as just to be above the grass, and in such a position that the sun may shine directly on the bulb for as large a portion of the day as possible. It should point directly to the sun at twelve o'clock.

How does the Surface of the Earth cool during the Night?

It cools by radiating the heat it had absorbed from the sun's rays during the day into space: this is called terrestrial radiation.

Why is a cloudy Night warmer than a clear one?

When the sky is covered with clouds a large portion of the heat radiated from the earth to the clouds is radiated back again by the clouds to the earth, and hence the temperature does not fall so far or so fast: this is because water vapour is a bad conductor. Also when the air is saturated with watery vapour the night is warmer: the drier the air the colder the night.

What Effect has the Deposition of Dew on the Temperature?

It should raise the temperature as long as the dew is falling, because in passing from a state of vapour to the liquid state latent heat is given out.

How is the Cold of Radiation measured?

By means of the minimum black-bulb thermometer, an ordinary minimum thermometer with its bulb blackened. It should be placed like the maximum black-bulb thermometer.

What is Dew and how is it formed?

It is the watery vapour of the atmosphere condensed into visible drops. It occurs when the air is cooled below the temperature at which it is able to hold the watery vapour present in suspension. The hotter the air the more watery vapour is it able to hold in suspension; but during the night, as the earth cools by radiation, the layer of air next its surface is cooled below the point at which it can hold the vapour present in suspension, the excess being deposited as "dew." The same phenomena are seen when a glass of cold water is left for a little while in a crowded room; and the moisture on the walls and window panes of crowded rooms is due to the same cause. The quantity of dew deposited depends on the degree of cold produced, and the amount of watery vapour in the air.

What other Conditions affect its Formation?

It is not deposited in cloudy weather because the clouds prevent the loss of heat by radiation, nor in windy weather, because the wind constantly renews the air in contact with the ground and thus prevents the temperature from falling sufficiently low. It is rarely deposited on the surface of deep water, because the temperature of water falls so slowly and is hardly ever low enough, as the cold water sinks, and hot comes to the surface in its place.

What is Hoar Frost?

It is dew deposited when the temperature is below the freezing point, or rather, it freezes as it is deposited —frozen dew.

What Effects are produced by Lakes on Climate?

If the lake is too deep to freeze then it renders the winter more mild on its shores, and also modifies the excessive heat of summer. If, however, the lakes are frozen it does not modify the severe cold of winter, though it tempers the summer heat: it is thus in North America, where the large lakes are frozen over, and here, therefore, there is a very severe winter and a summer of insular coolness. The sea also modifies the climate as it is very rarely frozen over.

What Effect do Forests exert?

The temperature is warmer at the base of a mountain and up its sides when the slopes above are covered with trees.

How is this?

(1) The trees lessen radiation from the surface they cover, and (2) they tend to stop the passage of descending currents of cold air.

What is the Importance of this Fact?

It is important for invalids, as it has been shown that when the temperature falls beyond a certain point the death-rate rises in the same proportion.

What is the best Position for a Dwelling?

Dwellings best protected from severe cold are those situated on a gentle slope a little above the plain or valley from which it rises, having a southern exposure, and the ground behind planted with trees; sleeping rooms to be in the higher flats, as at a little height from the ground the night temperature may be many degrees higher than what prevails near the ground. In camp-

ing out, for example, the tent should be placed on a rising knoll or other eminence, as the temperature is higher there than in hollows, even though close at hand; this is shown by the natural choice of resting ground at night by cattle and sheep, who select the higher ground in preference to hollows.

What is the "Gulf Stream"?

It is a great ocean current that starts from the Strait of Florida and flows northwards—or rather in a north-easterly direction—forming the chief part of the North Atlantic Ocean. It is much warmer than the rest of the ocean near it.

What is the Effect of this great Current?

It has a most beneficial effect in modifying the rigours of our northern climate; it raises the temperature of Shetland 39°, and of London 21° above what would probably otherwise be their winter temperature—Shetland 3° and London 17°. It also makes the west coast of the British Islands warmer than the east coast, and the heat of the west coast increases as we pass southwards, while the temperature of the east is the same all over. The temperature of the south-west of England and Ireland is 4° higher than the west coast of Scotland. This explains the value of the Isle of Wight as a winter resort to those who require a mild winter climate; but the south-west of England and Ireland are also good.

What is the Effect of Mountain Ranges on Temperature?

Mountain chains deprive the winds that blow over them of their moisture, and thus cause colder winters and hotter summers in places to the leeward, as com-

pared with places to the windward, as they thus remove the protecting watery vapour and expose them more fully to the effects of solar and terrestrial radiation.

Give Examples.

Norway and Sweden abroad; and at home, the east and west coasts. For the same reasons the rainfall on the side turned towards the prevailing wind is greater than the other—*e.g.* the west coast is more rainy than the east coast.

What is meant by "Isothermal Lines"?

They are lines on a map or chart drawn through all places having the same mean annual temperature.

What other Lines are there like these?

1. Isochemals, or lines of equal WINTER temperature.
2. Isotherals, or lines of equal SUMMER temperature.

What is the Hygrometer?

It is the instrument for ascertaining the amount of watery vapour in the atmosphere.

Name some of the Varieties.

1. The HAIR HYGROMETER of Saussure. The hair is attached to a lever, and when the air is damp it absorbs moisture, and becomes shorter. Its principle is absorption: it is also called a hygroscope.

2. DANIELL'S and REGNAULT'S HYGROMETERS, condensing hygrometer or dew point instruments.

3. The usual method is by the DRY and WET BULB THERMOMETERS, a hygrometer of evaporation, also called a psychrometer.

What would be the Result if the Air were perfectly free from Watery Vapour?

The air would permit the sun's rays to pass through it unimpeded, so that during the day the sun would burn up everything, and then at night the radiation from the surface of the earth would be so free and rapid that everything would be destroyed by intense cold. The air, in fact, would be perfectly transparent to the rays of heat—DIATHERMANOUS.

Where is this observed to a limited Extent?

On very high mountains—*e.g.* the Alps, where the sun is scorching during the day and the cold very intense at night. It is also observed in the polar regions to a certain extent, where the pitch on the side of the ship next the sun may be melted while ice is forming on the other side—the side away from the sun, and therefore in the shade.

What are the Kinds of Clouds?

The simple varieties are—

1. Cirrus (CIRRUS, a curl).
2. Cumulus (CUMULUS, a heap)—the cloud of the day.
3. Stratus (STRATUS, spread or laid or a layer)—the cloud of the night.

Two or more of the above may be combined in varying proportions, and are named accordingly—*e.g.* NIMBUS or the rain cloud is cumulo-cirro-stratus.

How is the Rainfall estimated?

By means of a RAIN-GAUGE. The simplest form consists of a funnel opening into a receiver in which the rain is collected, and from which it can be withdrawn and

measured : the funnel catches the rain, and also prevents evaporation, but its rim must be truly horizontal, or else it will catch too much or too little, according to the direction and force of the wind.

How is the Gauge to be Placed ?

It should be placed at least six inches from the ground to avoid splashing, and in the centre of a level open plot; the nearer the earth it is the more it catches.

Give a few Mean Annual Rainfalls.

Edinburgh and London - -	24 inches.
Liverpool and Manchester - -	35 to 36 inches.
Dublin - - - - -	30 inches.
Glasgow - - - - -	40 inches.

What is a Rainy Day ?

A fall of rain equal to ·01 or $\frac{1}{100}$ of an inch.

How is the Velocity of the Wind measured ?

Usually by the Hemispherical-Cup Anemometer (Robinson's Anemometer). It consists of four hollow hemispheres or cups screwed on to the ends of two horizontal rods crossing each other at right angles, and supported on a vertical axis which turns freely. When placed in the wind the cups revolve like a windmill, and the arms are of such a length that when a mile of wind has passed the anemometer 500 revolutions are registered on the dial of the instrument.

How is the Force of the Wind measured ?

By means of a water manometer.

What is the Cause of the Discomfort produced by the "East Winds"?

It is because they are so very dry and cold, and a wind of this character, wherever it comes from, is always as injurious to animals and plants as the true "east winds": they probably come from Siberia, in Russia.

What are the Causes of the Winds?

1. Unequal atmospheric pressure: winds blow from a region of a higher to a region of lower pressure: hot air is lighter and ascends, and the cold rushes in to take its place; hence differences in temperature at different parts of the globe is probably one of the most important causes of the wind.

2. Another equally important cause of a lowering of atmospheric pressure is the presence of an excessive amount of moisture or aqueous vapour in the atmosphere.

3. A third cause is the rotation of the earth.

How is Sunshine recorded?

Different apparatus are employed for this purpose—for example, the sun is made to focus its rays through a glass sphere upon a sheet of paper. The rays sharply focussed through the glass burn a path on the paper, and so make a chart of their duration. The paper is divided into spaces measured to certain times. Campbell Stokes' and Whipple Cassella's act on the foregoing principle. Other methods entail the employment of photography or specially sensitised paper.

What is the Definition of the Dew-point?

It is the temperature at which the moisture present in the air would suffice to saturate it. If the temperature

of the air containing a certain amount of moisture be lowered below the dew-point, the moisture will be deposited in the form of dewdrops.

What is the Drying Power of the Air?

It is the capacity of the air to absorb more moisture than it already contains.

What is understood by Saturation?

It is expressed in terms of the pressure which the aqueous vapour present in the atmosphere exerts at the earth's surface, a pressure proportionate to its weight. The amount of moisture which dry air can absorb depends entirely upon the temperature of the air. The point of saturation is therefore reached when the air has absorbed all the moisture it is capable of absorbing.

What is Absolute Humidity?

It is the actual moisture in the air, and is expressed in the same terms as the saturation. *Relative Humidity* is the moisture present in the air expressed as a percentage of the amount of moisture which would be present if the air were saturated at that temperature.

PUBLIC HEALTH

EPIDEMIOLOGY

What is meant by "Endemic"?

Diseases that are more or less limited to certain geographical areas, and always more or less present among the inhabitants of these areas, are said to be "ENDEMIC" to these localities.

Give Examples?

Yellow Fever in the West Indies.
Cholera in India.

What is "Epidemic"?

When a disease spreads rapidly so as to incapacitate and destroy great numbers of the people, it is said to be "epidemic."

What is "Pandemic"?

Diseases that have no special local habitat—*e.g.* small-pox, measles, etc.

How is Cholera propagated?

By infection in the matters discharged by purging and vomiting. Most commonly spread through the agency of water and milk. Clothes, etc., soiled with cholera discharges, if not disinfected, long retain their power of infection, they should therefore always be disinfected at once.

What are the Infectious Diseases that are compulsorily notifiable?

Typhus, typhoid, continued, relapsing fever, scarlet fever, cholera, diphtheria, membranous croup, erysipelas, puerperal fever, smallpox.

What are the Agencies involved in the Spread of Scarlet Fever ?

Infected milk supplies, and schools.

When is the Disease most prevalent and fatal ?

During the months of October and November.

What are Return Cases of Scarlet Fever, and how may they be explained ?

They are believed to be due to the carrying of infection by patients discharged from hospital to other members of the same family or school companions and so on. They comprise almost 3 per cent. of the total cases treated in hospital. Faulty disinfection of books and clothing, the premature discharge of patients, and the recurrence of nasal and other discharges have been given as reasons to account for return cases.

How might Return Cases be reduced in number ?

By carefully instructing parents to keep children apart for a week or ten days after their discharge from hospital. By the discovery of the real pathogenic organism, so as to enable bacteriological diagnosis to be made, as in the case of diphtheria.

At what Age is the Mortality from Measles greatest ?

Over 90 per cent. of the deaths are among children under 5 years of age. The death-rate during the ten years 1861-70 was 0·44 per 1000 living, and during 1881-1890 the death rate was 3·1 of those under 5 years of age.

What are the Characteristics of Measles Epidemics ?

They tend to recur every two years in large towns and are most intense in November, December and January. There may be another wave in May and June.

What Effect has School Closure in arresting the Spread of Measles ?

In country districts school closure may, and often does, prove a satisfactory means towards arresting epidemics, but in towns

the experiment has not been attended with success. The disbanding of infant departments may, however, effect some good purpose.

What is the Mortality from Whooping Cough?

Forty per eent. of the mortality is during the first year, 30 in the second, 15 in the third and 6 per cent. in the fourth. During the deeade 1881-1890 the death rate was 3·4 of those under 5 years of age. The death rate for all ages was 0·45 per 1000.

When is the Mortality and Incidence of Smallpox greatest?

During the first six months of the year, rising to a maximum towards the end of May. It falls in June and does not rise again till Deeember or January.

What Steps should be taken by Local Authorities to arrest the Spread of Smallpox?

Notifieation, isolation, disinfeetion, vaeination and revaeeination, quarantining of eontaets for fourteen days. Notifieation of ehieken-pox; securing of lists of those going to and leaving lodging houses. Power to do this is afforded by the Public Health (Seot.) Aet 1897.

What is the Period of Infectivity of Scarlet Fever?

As long as there are nasal discharges, sore throats or abrasions about the lips, eyes or ears the danger of infection is greatest. Desquamation is not now looked upon as being of mueh eonse quenee in spreading infeetion.

What is the Case Mortality of Scarlet Fever?

Between 2 and 3 per eent.

What is the Seasonal Incidence of Whooping Cough?

Outbreaks of this disease and measles often oeeur about the same time. For whooping cough the seasonal eurve attains its maximum late in March or early in April.

What is the Death Rate?

It is the most fatal of all the infectious diseases of children under 5. In the first year 40 per cent. of the mortality occurs, 30 per cent. in the second, 15 per cent. in the third and 6 per cent. in the fourth. The death rate between 1881-1890 was 3·4 per 1000 under 5 years of age; for measles it was 3·1.

What is Malta or Mediterranean Fever?

A disease often having a prolonged course and showing exacerbations. The disease is due to an organism called the *micrococcus melitensis*. This micro-organism may be harboured by goats and spread in their milk. Goats' milk is the usual source of supply in Malta.

What are the Strongest Arguments in favour of Vaccination?

In the pre-vaccination days smallpox was specially fatal among infants, now the incidence of the disease is chiefly among adults. Smallpox does not attack those in attendance upon the disease if they be well protected by vaccination. It selects unprotected persons, as it did the unvaccinated Leicester nurses. Smallpox is scarcely known in Germany, where vaccination and re-vaccination are compulsory. The disease is still commonly encountered in Russia, Austria and Italy. In Germany special hospitals for the isolation of smallpox are not even provided. Finally, the experiences of those who have had to combat epidemics must be of more value than the theories of rabid opponents, most of whom are laymen.

It is said that Smallpox may be aerially spread—is this true?

It has never been conclusively proved that the poison can be spread through the air. It may be possible that infected matter, such as scales of skin, etc., can be wafted here and there in the neighbourhood of hospital wards, but repeatedly the theory of aerial spread of smallpox has been broken down by those who have gone carefully into the histories of the cases as they occurred. At Sheffield, for instance, visitors slept in

the smallpox hospital and spread infection broadcast, yet this was a case cited in favour of the aerial spread of the disease. It is just as likely that laxity in administration of the hospital may exert a large influence in permitting the diffusion of infection in the immediate neighbourhood of smallpox hospitals.

How may Anthrax be spread ?

It may be spread among animals by their consuming infected food, such as fodder which has grown in places where animals dead of anthrax have been buried. Oil cake is believed to cause such spread of infection, because the cotton seed is grown in countries where precautions as to proper disposal of infected carcasses are not taken. From animals anthrax may be spread in the form of malignant pustule, or among wool-sorters as wool-sorters' disease. Infection may thus occur through the alimentary canal, lungs or skin.

How may Infection among Wool-sorters be combated ?

By having well-ventilated premises, washing and disinfecting the wools, careful washing of hands of those employed and the changing of working clothes before going home.

How should Anthrax Carcasses be dealt with ?

They should be buried in a trench 6 feet deep, and surrounded by a 6-inch layer of quicklime. The grave must not be in pastureland nor near wells. As an alternative the carcasses should be cremated, preferably in a refuse destructor.

When is Cholera most prevalent, and where ?

The disease is most common during the warmer months of the year—namely June, July and August. Moderate rainfall favours spread; but heavy rains and cold weather arrest its progress. In Lower Bengal the disease is endemic, and among negroes it is specially fatal.

What is the Materies Morbi of Cholera ?

It is due to the Comma bacillus. The disease is spread in the same way as enteric fever and epidemic diarrhœa.

What Agents favour the Spread of the Disease ?

Where the person suffering from cholera goes the disease follows. The disease depends upon the filth facilities, such as foul water, polluted soil and air. Such conditions are to be found in most Eastern towns.

When is Epidemic Diarrhœa most prevalent and to what is it believed to be due ?

Chiefly prevalent during July and August. It is a bacterial disease, the incidence of the disease being influenced by prevailing temperature, deficiency of rainfall, surface dust and food pollution.

What is the Mortality ?

In the epidemic form the disease may account for 25 deaths per 1000 infants.

What Remedies have been advocated ?

Notification of all cases, the employment of health visitors, the sale of sterilised or suitably prepared milk and the issuing of pamphlets offering advice and instruction to mothers.

How is the Infection of Enteric Fever spread ?

By means of infected water and food supplies, such as milk, shellfish, vegetables. The fæces and urine convey infection, and investigation has shown that "carrier cases" are capable of much mischief, especially in large institutions such as reformatories, asylums, etc.

What are the Best Safeguards against the Spread of Enteric ?

Well-filtered water supplies, pure foods and good sanitary environment—in other words, the paving of back courts; the

riddance of privies and privy middens, allaying of dust and general cleanliness of communities; proper isolation, with disinfection of houses, clothing and discharges.

What is the Cause of Malaria?

It is spread by the mosquito (genus Anopheles) which infects the human host with the malarial parasite. These parasites (Sporozoa) propagate in the blood and while there pass through a cycle of development.

What is the Usual Cycle of the Parasite in the Human Blood?

After the parasites become mature they split up into amœboid bodies called "rosette" forms. These new bodies are called "sporocytes," which become diffused in the blood in consequence of the breaking up of the corpuscles which contained them. The spleen receives many sporocytes and phagocytes kill others. Fresh infection is brought about by some phagocytes attaching themselves to and penetrating red blood corpuscles. This asexual cycle in the human host is known as the "Cycle of Golgi."

What are the Three Leading Forms of Malaria?

1. Quartan type, which is marked by fever every third day and depends upon a parasite which takes 12 hours to pass through its cycle of development.
2. Benign or mild tertian, in which the parasite takes 48 hours to pass through its cycle.
3. Malignant infectious type, in which the parasites assume a special crescentic shape in the blood corpuscles.

How may Malaria be combated?

By the prevention of mosquito breeding; the destruction of mosquitoes; guarding against bites of the insects; the use of quinine; isolation of infected persons.

How is Yellow Fever spread?

It is no longer believed to be a disease spread by swampy soil nor by infected water and milk. A recent American commission investigating the disease in Cuba came to the conclusion that the mosquito known as *Stegomyia fasciata* was mainly instrumental in spreading yellow fever.

Enumerate and describe the Parasitic Diseases.

Ringworm, produced by a fungus which prefers to attack the scalp. The fungus is called the *tricophyton tonsurans*. Causes circular itchy patches. Fungus can be microscopically demonstrated by soaking a hair in weak potash solution and then examining. *Achorion Schönleinii* causes *favus*, the crusts formed are dry and cup-shaped. *Chloasma*, caused by *microsporon furfur*, forms fawn-coloured patches especially on front of chest and neck. *Thrush*, caused by *Oidium Albicans*, seen in the mouths of children in the form of small circular white patches, probably caused by oidium in milk. The animal parasites comprise *scabies*, produced by the *Acarus Scabiei*. The louse or pediculus also attacks children's hair. In the tropics the *Pulex penetrans* is encountered as well as the *guinea worm, Filaria medinensis*. How the latter gains entrance to the human body is not quite known. It is suggested that drinking water may be a possible vehicle. Worm $\frac{1}{10}$th inch in diameter and from 1 to 3 feet in length. Part of its life is spent in man the other in freshwater crustacean known as cyclops. *Filaria Sanguinis Hominis.*—A hairlike worm from 3 to 4 inches in length found in the blood of those who have lived in the tropics; associated with existence of chyluria and elephantiasis. The parent worm is known as *Filaria Bancrofti*. The embryos shed into blood stream are known as *Filaria sanguinis hominis nocturna*. Filaria is swallowed by man in water. Therefore all water should be boiled and filtered in filaria districts. *Dochmius Duodenalis.*—Short worm about $\frac{1}{2}$ inch long, which attaches itself to villi of small intestine; common in Egypt and Italy; causes fatal anæmia, known as *ankylostomiasis*.

Worm infects man either in earth adhering to food or in water. Infection may also be through skin. Miners may be infected by dirty hands or dirty pipes. *Bilharzia Hæmatobia.*—About $\frac{1}{4}$ inch long, infects veins of large intestine, bladder and kidney and by establishing inflammation reveals its presence by hamaturia. Prevails in Egypt and South Africa. Urine contains ova, which are about $\frac{1}{180}$ inch in size, each armed with a spike. Reaches human body through water. The intermediate hosts in the water are anthropodes which, when drunk, initiate the mischief in man. *Trichina Spiralis.*—From $\frac{1}{8}$ to inch in length. Attacks man, pigs, etc., producing *trichinosis*. Ovoid cysts are found in the muscle substances, each cyst containing an immature trichina. Young worms set free in the intestines rapidly penetrate the intestinal walls to reach the muscles. *Ascarides.*—Of these there are three varieties: lumbricus, threadworm and *tricocephalus dispar*. *Tapeworms.*—The head or *scolex* is embedded in the muscle with its bladderlike expansion known as the *cysticercus*. The adult worm shows a series of segments, *proglottides*, each segment producing eggs or ova. These escape and are voided in the excreta. Some may be swallowed by animals in the grass, etc. Man is more subject to tapeworm than cysticercus stage. *Tænia solium*, common in man, may be 7 feet long. Head carries four suckers with double circle of hooklets surrounded by a prominence known as a rostellum—its cysticercus stage is known as cellulosæ, encountered in pigs as "pig measles." Measly pork it is therefore which causes *Tænia solium* in man. *Tænia mediocanellata.*—Head has four suckers but neither hooklets nor rostellum. Cysticercus is the *bovis*. *Bothriocephalus latus* may reach a length of 30 feet. Ovoid head marked by two longitudinal suckers. It has no hooklets. Embryo ciliated and found in river water. Cysticercus found in fish, especially pike. *Hydatids.*—Cysts found chiefly in liver. Hydatids are really cysticercus stage of *Tænia echinococcus*, peculiar to dog and wolf. Worm has only four segments, of which the last contains the reproductive organs.

What Precautions should be taken against the Spread of Cholera and Enteric Fever?

1. Immediate and searching examination of all sources of water supply should be made in all cases where the source is in any degree open to the suspicion of impurity. Where pollution is discovered, everything practicable should be done to prevent the pollution from continuing, or, if this object cannot be obtained, to prevent the water from being drunk. Cisterns should be cleaned, and any connections of waste-pipes with drains should be severed.

2. Simultaneously, there should be immediate thorough removal of every sort of house-refuse and other filth which has accumulated, future accumulations of the same sort should be prevented; attention should be given to all defects of house drains as well as thorough washing and lime-washing of dirty premises.

Also all choleraic discharges should be at once disinfected before they are cast into the water-closet, etc. All clothes, etc., soiled with the discharges disinfected; and lastly no leakage from cesspools or drains into wells or other sources of drinking water should be overlooked.

What Points should be attended to during an Outbreak of Typhoid?

Disinfect at once all the evacuations before they are poured out into the water-closet. Examine the water and milk supply, close polluted wells. Pave back-courts and do away with privy middens.

What Conditions generate and spread Typhus Fever?

Overcrowding, deficient ventilation, squalor, dirt and want. The cutaneous and respiratory exhalations contain and convey the infection. It does not, however, travel far through the air; and if the room is well ventilated the attendants run but little risk. The poison rises to upper storeys.

What other Names has this Fever?

Jail fever, ship fever, camp fever, hospital fever. It is also one form of "Brain fever," so called because of the frequency of cerebral complications.

What Precautions should be adopted in a Case of this Fever?

1. Isolate the sick.
2. Attendants should have had the disease.
3. Visitors must not be permitted.
4. The room must be well ventilated.
5. All useless furniture, carpets and curtains removed.
6. Bedding and clothing disinfected or destroyed.
7. After convalescence, every piece of furniture and the whole room should be disinfected.

What Precautions should be taken on the Outbreak of Small-Pox?

1. Immediate and complete isolation of the infected person.
2. Vaccinate those not already vaccinated, and re-vaccinate those already vaccinated.
3. Careful disinfection of the house, and destruction of all infected bedding, clothing, etc.

When is the Person free from Infection?

Not till all the crusts have fallen off and the scars all healed; the body sponged with water and some disinfectant, and bathed several times.

Give a Short Sketch of the Hygienic Treatment of Phthisis?

1. Plenty of pure fresh air.
2. Gentle exercise in the open air daily.
3. A high, dry and equable climate, even though cold, as phthisis is most common in low-lying damp places, but is not a disease of the Arctic regions. High winds should be avoided: a temperature of about 60° F. is the best.
4. Careful and proper dress.

5. Rest from sunset to sunrise.
6. Outdoor work in fresh air.
7. Cleanliness of body.

Give a Short Historical Sketch of Typhus Fever?

It was first known as the "Black Assizes," Old Bailey, in 1756, where judges and jurors died, infected by the prisoners; hence, it was called "Jail fever." It has been the great scourge of armies in temperate climates, just as cholera and yellow fever are in the tropics. It arises wherever persons are crowded together in ill-ventilated and unwholesome dwellings. In 1489, 17,000 of the troops of Ferdinand besieging Granada were destroyed by it. So also in the army of Charles V. during the siege of Metz; and in 1556, in the army of Maximilian II., in Hungary, and from this spread over all Europe. In 1620 the Bavarian army lost 20,000 by it in a few months, and again a large number in 1812-1813. In the spring of 1856, in the Crimean War, 17,000 of the French perished in three months.

How does Relapsing Fever arise?

Usually from poverty and exhaustion following on long-continued privation, together with overcrowding, poverty, and destitution; hence, it is called "famine fever" or "hunger pest." A spirillum is found in the blood, the SPIRILLUM OBERMEIRI.

Give some Examples?

It spread in various parts of Scotland in 1817-1818; the Edinburgh and Leith epidemic in 1843; in the summer of 1855, after the hardships of the preceding winter, it spread among the British troops in the Crimea; it also spread in America from the Irish emigrants, but since then it seems to have died out.

What is the Origin of Yellow Fever?

It is usually limited to 40° N. latitude and 20° S. latitude,

and a temperature of 72° F. at least. It is usually endemic in low districts on the sea-coast, and rarely occurs above 2500 feet above the sea-level.

It is characterised by "black vomit," black stools, slow and intermittent pulse: the black vomit and stools are probably due to hæmorrhage: the urine is often suppressed. The black vomit is very acid and contains ammonia combined; caustic potash dissolves the sediment and sets the ammonia free.

What are "Glanders" and "Farcy"?

GLANDERS is characterised by congestion of the nasal mucous membrane, with glutinous secretion and the presence of soft-chancrelike sores; the disease spreads into the various sinuses connected with the nasal cavities, as the frontal, ethmoid and sphenoid, and also to the trachea and bronchi. There are also pustular eruptions on the skin, like small-pox or ecthyma, followed by suppuration or gangrenous ulceration of various parts. One or other of the above may alone be present, or they may be combined. Besides this, there is fever of a low and malignant type.

FARCY is a general inflammation of the lymphatic glands and vessels, as well as the tissue around, forming "farcy buds" or "buttons"; these suppurate and secrete a specific virus. "Button" farcy is limited to the glands and vessels. It will be seen, therefore, that "glanders" affects the nasal passages chiefly, whereas "farcy" affects the lymphatics; but glanders may produce farcy, and *vice versa*.

How does this Disease originate?

It arises in the horse, ass or mule; in the horse, from bad ventilation—*e.g.* on board ship, from dirty close stables, bad food and severe weather. It is contagious, and the affected animal must be killed, and all animals touched by the disease. It is spread by drinking from the same pail, or from licking the rack, etc.

For those attending to horses, it is necessary to avoid contact with the secretions of the mucous membrane, especially if there is an abrasion; if an abrasion is inoculated, it must be cauterised and malleiu used.

What is Splenic Fever?

It is a disease that is found among horned cattle, sheep and horses, and in a few others.

What other Names are applied to it?

In England it is called splenic fever or apoplexy, anthrax, and Siberian plague (in horses).

In Germany, it is known as Miltzbrand and anthrax.

In France, it is called charbon, sang de rate, and mal de rate.

Does the Disease occur in Man?

Yes; it occurs in man by direct contagion from animals.

What are its Varieties?

1. External local form—"malignant pustule."
2. Internal form, with various names, as—
3. Wool-sorters' disease.

What are the Appearances in Cattle?

The spleen is enlarged and swollen, and looks as if filled with a blood clot—hence the name "splenic apoplexy"; there are also hæmorrhages in internal organs, as the lungs, walls of heart, kidney and brain. There are glandular swellings in the neck and mediastinum, especially in sheep, and effusion into serous cavities. In the blood, large numbers of the BACILLUS ANTHRACIS are found.

What is "Malignant Pustule"?

The external local form of anthrax in man. It is produced by contagion from animals, or from the hides of animals dying from this disease.

It may arise—

1. From direct inoculation, as in butchers and farriers.
2. From hair, skins, wool, etc., as in hair-sorters, rag-pickers, wool-sorters, upholsterers, etc.

What is the Appearance of the Sore?

It is found on the exposed parts of the body, as the face, neck, hands, and arms. It is at first a small hard pimple, red and angry looking, with a red areola round it, like the bite of a gnat; a little vesicle forms, and the part becomes gangrenous, forming a hard, black, depressed eschar, with a crop of vesicles round it; the spreading edge of the sore is raised, though the gangrenous part is depressed. Beyond the vesicles is a red erysipelatous-like blush. The tissues are full of the bacillus, the lymphatics are inflamed and enlarged, and death occurs from septic poisoning, or it may pass into some of the internal organs.

What are the Features of the Internal Forms?

The lesion occurs in the alimentary canal and the respiratory tract. The bronchial and mediastinal glands are swollen: there may also be hæmorrhage in the lungs and brain, mediastinal cellulitis, pleural effusion. The mucous membrane of the traehea and bronchi is swollen and infiltrated with bacilli—in the tissues and lymphatics, not in the blood-vessels.

FOOD

What is the Composition of the Human Body?

Organised substances	Albumen	20·7	= 23·2
	Fatty matters	2·5	
Inorganic substances	Salts	9·2	= 76·8
	Water	67·6	
			100·0

What Amount of Nitrogen and Carbon does the Body require in Twenty-four Hours?

300 grains of nitrogen.
4800 grains of carbon.

Or in the proportion of 1 of nitrogen to 16 of carbon.

What is the Ratio of these Elements in Albumen and Bread respectively?

In albumen the ratio is 1 of nitrogen to 3·5 of carbon.
In bread it is 1of nitrogen to 30 of carbon.

What would be the Result of living on either alone?

On albumen alone there would be a great waste of nitrogen; because to get the carbon we would have to take 7547 grains, and this contains 1132 grains of nitrogen, or almost four times too much. The result of this is that there is a great deal of profitless labour thrown on the excretory organs, in order to get rid of the excess, injuring the kidneys, and inducing the uric acid diathesis.

If one lives on bread alone, there is a great waste of carbon; for in order to get enough nitrogen we must take 9000 grains of carbon, which is double the amount required: hence the necessity for a mixed diet.

In order to get 4000 grains of carbon from meat, we would require to eat four pounds of fatless meat, whereas three-quarters of a pound will yield 300 grains of nitrogen—*e.g.* 2 lb of bread and ¾ lb of meat, with a little dripping or butter, will give the proper amount of carbon and nitrogen without waste.

What is the Weight of a Full-grown Man?

About 154 lb: consisting of—
88 lb of water and
66 lb of solid matters.

What are the Gains and Losses of such a Body?

Gain per day	*Grains*
Solid dry food	8,000
Oxygen	10,000
Water	36,500
	54,500

Loss per day—	*Grains*
Water	40,000
Other matters	14,500
	54,500

What Amount of Work should such a Body perform?

From 340 to 450 foot-tons—*i.e.* to lift this number of tons one foot high or its equivalent.

Give a Diet Table for Ordinary Work?

	Ounces		*Grammes*		*Grains*
Proteids	4·5	or	130	or	2000
Amyloids	14·2	or	404	or	4400
Fats .	3·0	or	84	or	1200
Salts .	1·0	or	30	or	400
Water .					36,500
	22·7				44,500

It will be seen that about 23 oz. of solid dry food is required, one-fifth of which is nitrogenous; half the ordinary food is water, so that this will correspond to 46 oz. of ordinary water, leaving 50 to 80 ounces of water to be taken by other means.

The force-producing value of the diet is nearly 4000 foot-tons.

The fæces passed per day, after such a diet, would amount to about 2800 grains, containing about 800 grains of solid matters.

Give a Diet for Idleness?

	Ounces
Proteids	2·5
Fats	1·0
Carbo-hydrates	12·0
Salts	0·5

Water as before.

Give a Hard Work Diet?

	Ounces		
Proteids	6	to	7
Fats	3·5	to	4·6
Carbo-hydrates	18	to	22
Salts	1·2	to	1·5

Water, *ad libitum.*

One hundred persons exerete daily 71·5 lb of carbon and 4·5 lb of nitrogen: to make good this waste in a cheap manner, say in a prison, give bread and water; but this is wasteful of earbon, since we would require 380 lb of bread to give suffieient nitrogen, but in this there is 128·5 lb of carbon, or 57 lb too mueh. If we use purely animal diet we would require 354 lb of lean meat to get enough of earbon; but this amount of lean meat eontains 110 lb of nitrogen, or 105 lb too mueh. This also would be wasteful, besides injuring the person's health.

What is the Proper Proportion to use?

For one hundred persons, as above, use—
200 lb of bread.
60 lb of meat, since—

	Carbon	*Nitrogen*
200 lb of bread eontains	60	2
60 lb of meat eontains	12	$2\frac{1}{4}$
Total,	72 lb	$4\frac{1}{4}$ lb

This is just suffieient to make up for the loss, but more would be given in aetual praetiee to have a margin for emer-

geneies. It would also depend on the work done by the prisoner. The work done by the body is reekoned as equivalent to raising a man of 10 stones through 10,000 feet: in penal serviee, one-half more is added to this—*i.e.* to raise 10 stones through 15,000 feet.

NOTE—10,000 feet is about equal to $3\frac{1}{3}$ miles.

In what Ways can the Energy for this be obatined, or at what Expense?

Say—

3·5 lb of lean meat, eost 3s. 6d.
One half lb suet, eost $5\frac{1}{2}$d.
Three quarts of milk, eost 6d.
Cheese, say 10d. worth, is as good as the 3·5 lb of meat.

Other methods would be by using apples and baeon, or apples and eheese.

One hundred prisoners at hard labour would require—

58 lb of bread,
54 lb lean meat, and
63 lb of potatoes.

This would be JUST ENOUGH for the needs of the body and for the work done; but it would be advisable to add to this some milk or porridge.

How do you judge if the Diet be sufficient—e.g. *in Prisons?*

By the patient's general health, and by weighing him carefully every week, so as to see whether he is gaining or losing weight.

What Purposes do the various Food Stuffs serve?

The PROTEIDS determine the absorption of oxygen and build up and repair tissues. The FATS and CARBOHYDRATES are the great and direet sources of energy. The SALTS determine osmosis and nutritive tissue ehanges.

Give Examples of the Food Stuffs.

1. Proteids, as—
   - Albumen, as in eggs and meat.
   - Casein, in milk.
   - Myosin, in muscle.
   - Fibrin.
   - Gluten.
   - Legumin.

2. Fats, as—
   - Suet.
   - Lard.
   - Marrow.
   - Butter.
   - Oils.

3. Carbohydrates, as—
   - Cane Sugar.
   - Grape Sugar.
   - Milk Sugar.
   - Starch.
   - Arrowroot.
   - Rice.
   - Potatoes.

What is the Composition of Milk?

	Cow	*Woman*
Proteids (casein and albumen) .	4·1	3·35
Fats (butter)	3·9	3·34
Milk sugar	5·2	3·77
Salts	0·8	
Water	86	89·54
	100·00	100·00

It will be observed that woman's milk is more watery, and that cow's milk contains 14 per cent. of solids, while woman's milk contains only 10 to 11 per cent. The specific gravity of milk varies from 1026 to 1030. Asses' milk most closely resembles human milk.

Could an Adult live on Milk alone?

He would require 8 to 10 pints in twenty-four hours, but this would give him an excess of water and fatty matters, which is disadvantageous to the adult, though it is specially suitable for young persons.

What Salts are present in Milk?

Salts of the alkalies and earths, just like those of the blood, potassium salts being present in greatest abundance—phosphate of potassium, chloride of potassium, much phosphate of calcium, and traces of phosphate of iron.

What is the Composition of Cheese?

Proteids	33·5
Fats	24·3
Salts	5·4
Water	36·8

The cheese contains much nitrogen in small bulk, so that ½ lb of good cheese is equal to 1 lb of beef. In "ripe" cheese there is less casein and more fat.

What is the Composition of Eggs?

An egg weighs about 2 oz., and consists of—

10 parts of shell,
60 parts of "white,"
30 parts of yolk.

A single egg contains as much nutriment as 2 oz. of beef, and four eggs therefore are equivalent to ½ lb of beef. The yolk contains much lecithin—a peculiar phosphorised and nitrogenised fat, found specially in nerve tissue—and is therefore useful for brain work. Eggs contain all that is necessary for the development of the young animal—except oxygen, which is absorbed from the air. The "white" consists of albumen and water; the albumen is very soluble, and enclosed in thin-walled cells; the yolk forms a yellowish emulsion. Lightly boiled eggs are more easily attacked by the gastric juice than either raw or when hard boiled.

How is the "Freshness" of Eggs to be tested?

By their specific gravity and transparency. Good eggs should sink in a 10 per cent. solution of common salt; when one looks through a good egg it is translucent, especially towards its centre.

Sketch an Ordinary Diet.

Meat	8 to 16	oz.
Bread	12 to 18	,,
Potatoes	6	,,
Milk	3	,,
Butter	1	,,
Sugar	1·2	,,
Salt	·25	,,
Tea	·25	,,
Coffee	·33	,,

How are the Tissues affected when Food is withheld?

The result is starvation: the body loses two-fifths of the entire weight, and will then probably die.

The tissues waste thus—

Adipose tissue	97	parts lost.
Spleen	63·1	,,
Liver	56·6	,,
Muscle	30·2	,,
Blood	17·6	,,
Brain and Spinal Cord, and Heart	0	

Probably the chief cause of death is loss of heat.

A woman requires one-tenth less food than the male.

Up to nine years of age the food should be chiefly milk and farinaceous food.

At ten years of age, the child requires half as much as a woman: at fourteen years of age as much as a woman.

Young growing lads require more food than full-grown men.

What are the Characteristics of Good Meat ?

The cut section should present a marbled appearanee, from the mixture of fat and muscle. The colour should not be too pale nor too dark. If pale and moist, it shows that the animal was young or diseased ; if dark and livid, it shows that the animal was not slaughtered, but died with the blood in it. The muscles of pork, veal and lamb are always pale. The musele and fat should be firm to the toueh, not wet nor sodden ; the fat should be free from hæmorrhagic points, and the suet fat should be hard and white. Any juice exuding from the meat should be small in amount, reddish in tint, and acid in reaction. The juiee of bad meat is alkaline or neutral. The fasciculi should not be large and coarse, and should be free from any mueilaginous or purulent-looking fluid in the tissue between.

The odour should be slight and not disagreeable ; if the odour is bad, it indieates putrefaction or disease : and this can best be detected by chopping a piece of the meat and drenching it with warm water, and then smelling the vapour given off ; or thrust a long clean knife into it, and smell it after withdrawal.

Also examine the ribs for pleuritie adhesions : the brain and liver for hydatids, and the lungs for abseesses. For parasites use the microscope.

What Diseases render Meat unfit for Human Food ?

1. Pleuro-pneumonia.
2. Generalised tuberculosis.
3. Rinderpest or cattle plague.
4. Anthrax.
5. Splenic apoplexy or " braxy " in the sheep.
6. Foot and mouth disease in the last stage.
7. Pig typhoid.
8. Pig measles.
9. Puerperal fever.
10. All aeute fevers.

What well-marked Affections are produced by Diseased Meat?

1. Trichinosis, by eating pork infested with the *trichina spiralis.*

2. Tænia solium, one form of tape-worm, from eating "measly pork"—pork infested with the *cysticercus cellulosæ.*

3. Tænia mediocanellata, another form of tape-worm, from eating measly beef—the most common form in this country.

What Means are used to prevent Outbreaks of Scurvy?

The use of lime juice, as well as fresh or preserved meats and vegetables. Fresh vegetables should always be carried on shipboard, notably raw potatoes, as they are very effective and will keep good for a long time.

What Infectious Diseases are conveyed by Milk?

1. Typhoid fever.
2. Scarlet fever.
3. Diphtheria.
4. Tuberculosis.

What is the Standard for Milk?

Three per cent. of fat, 8·5 per cent. solids not fat, and 11·5 per cent. total solids.

What is the Standard for Skimmed Milk?

Where the milk contains less than 9 per cent. of milk solids it shall be presumed not to be genuine skimmed milk.

Under what Authority are these Regulations framed?

The Board of Agriculture, by virtue of Section 4 of the Sale of Food and Drugs Act 1899, issued the milk regulations above quoted.

What is the Standard for Butter?

Must not contain an excess of 16 per cent. of water.

What are the Standards for Whisky, Brandy and other Spirits?

The allowable reduction of spirit shall be 25 per cent. under proof for brandy, whisky and rum, and 35 per cent. for gin.

What is the Standard for Margarine?

Must not contain more than 16 per cent. of water, and no more than 10 per cent. of butter fat.

What are the Provisions with Regard to the Exposure of Margarine for Sale?

Every package containing margarine shall be marked top, bottom and sides with the word Margarine in capital letters, each letter $\frac{3}{4}$ inch square. If exposed for retail the word Margarine must be affixed, each letter $1\frac{1}{2}$ inch square. When retailed must be in wrapper on which word Margarine *alone* appears, each letter $\frac{1}{2}$ inch square.

What is Milk-Blended Butter?

It is a mixture produced by mixing or blending butter with milk or cream other than condensed milk or cream. Milk-blended butter must not contain more than 24 per cent. of water.

BURIAL

What Points have to be attended to in Land Burial?

The cemetery should be at some distance beyond the town: the body should be buried at least 6 feet from the surface and only one body in each grave; plants of quick growth and dense foliage should be planted in the graveyard. The soil should be dry and well-drained, and of an open, porous nature.

What Area is required for a Town?

To calculate the area required for a town, take the death rate at 30 per 1000, and allow two square yards (or metres) for each grave—*i.e.* for the grave and space between it and the next.

Another plan is to allow a quarter to half an acre for every 1000 of the population.

What are the Objections to Cremation?

They are based purely on religious and sentimental grounds. Cost is also grudged. It is urged that in cases of poisoning all traces would be removed by incineration.

What are the Disadvantages of Earth Burial?

The land necessary is valuable and the areas required are large. Years may elapse ere the remains are thoroughly disintegrated; land, water and atmospheric pollution may take place.

WATER-CLOSETS

What are the Requirements of a good Water-Closet?

1. It should work effectually with a minimum supply of water.
2. It should be simple in construction and not liable to get out of order.
3. It should have an effectual seal.

What are the Objections to the Pan Closet?

It is the frequent cause of nuisance. The receiver becomes coated with fæcal matters, which remain moist and decompose. Gases form, and when the closet is opened they pass into the house. The D-trap is also one of the worst possible of traps. The dip pipe goes into the water from $\frac{1}{2}$ to $1\frac{1}{2}$ inches, and all sorts of dirt collects on its outside and the large space above it so that it cannot be cleaned out. The cistern which flushes this type of W.C. often supplies house holds with drinking water.

Is the Valve or Bramah Closet good?

Paper, etc., is apt to stick in the valve and make it leak. But with plenty of water, it is a very excellent closet. It

requires a flush of 8 gallons and is therefore somewhat extravagant.

What is the "Hopper" Closet?

It consists of a simple basin and a trap; the basin is pyramidal or hopper-shaped, and the trap a simple S bend.

What is a Waste-Water-Preventing Cistern?

The small cistern which supplies the W.C. with flushing water, generally 2 to 3 gallons in amount.

What are the Principal Tests for Drains?

The *water* or *hydraulic test*—generally used in connection with new systems. For old stoneware pipes the test is a very severe one. *Ball test*—used to clear new systems of projections. *Smoke test*—applied by smoke machine or smoke rocket. *Pneumatic or Air test* is severe and has the disadvantage that traces of leaks cannot be observed. *Chemical test*—breaking capsules of phosphorus or asafœtida inside the drains. *Oil of peppermint test*—seldom used in practice.

If required to pass under the House how should Drains be laid?

They should be embedded in concrete 6 inches thick and at the points where the drain enters and emerges from the building the wall should be arched. This renders the pipes watertight and relieves them from accidental pressure due to sinking of the wall. When drains are to pass under buildings iron and not stoneware pipes ought to be employed.

What Directions should Drains take?

Straight lines wherever possible. Should angles and bends be necessary, inspection manholes ought to be provided at every change of direction of the drain as well as every point where drains pin one another.

What are the Characteristics of a Good Trap?

It should have a seal of at least 3 inches, it should be self-

cleansing. Its outlet should be slightly lower and of smaller diameter than its inlet. It should have an inspection eye and an opening for ventilation. It should be made of impervious material.

What are the Advantages of Traps?

If they are well sealed and self-cleansing they prevent the passage of foul air, unless under great pressure. If not well sealed and self-cleansing they simply become small cesspools. Gases, however, *may* pass through water seals by diffusion.

How deep should the Water Seal be?

Two to three inches.

If the Trap is made of Lead, what Weight should be used? .

Use 7 to 8 lb lead to the superficial foot, never less than 6 lb lead; and if much hot water is to pass through do not use less than 8 lb lead.

How may Traps be cleaned?

By means of a cap and screw below the water dip and on the house side of the trap; this is not necessary in water-closet traps, because the hand can get down the basin to the bottom of the trap, but it is necessary in sink and lavatory traps.

Is the Gully form of Intercepting Trap good?

No; much water lodges in it, and filth as well, which decomposes, producing foul gas that passes up the waste pipe into the house; the water-trap, also, is not changed every time the trap is used. It does very well for yards and courts, and to catch the road detritus.

What is the Action of a Discharge of Water into a Drain?

Its action is double—driving and sucking: it drives before it and sucks after it, and unseals traps from momentum and syphonage unless they are ventilated. It will also force traps at lower levels as it shoots past the opening of the drain.

What Size of Ventilating Pipe should be used?

From 3 to 4 inches is large enough even for from four to six closets, one above the other.

How much Water should be allowed to flush a Water Closet?

Three gallons is probably the best; it should be delivered suddenly, so as to get rid of everything by one flush.

DISINFECTANTS

What is a "Disinfectant"?

A substance that can prevent infectious diseases from spreading, by destroying their specific poison, so that it loses its power to infect.

Give a List of the more Common Disinfectants?

Sunshine and fresh air.
Heat (steam).
Chlorine.
Nitrous Acid.
Iodine.
Bromine.
Sulphurous Acid.
Carbolic Acid.
Terebene.
Chloralum.
Chloride of Lime.
Sulphate of Copper.
Chloride of Zinc.
Green Copperas.

Is Chlorine a good Disinfectant?

Yes, in the presence of water it is very powerful; but it is not good for the sick-room, as it is too irritating for the respiratory passages.

How can it be produced?

1. In Small Quantity.
2. In Large Quantity.

It may be evolved slowly from—

(1) Chloride of lime (what is evolved is *hypochlorous acid* and not pure chlorine).
(2) From Condy's fluid and hydrochloric acid.
(3) From chlorate of potash and hydrochloric acid.

In large quantities from—

(1) Common salt, manganese dioxide, and sulphuric acid.
(2) From manganese dioxide and hydrochloric acid.
(3) Bleaching powder with some dilute sulphuric acid.

How is Nitrous Acid produced?

By means of strong nitric acid and copper filings.

Is it often used?

Not very; it is very good for removing foul odours, but cannot be used in living rooms, as the fumes are very irritating to the respiratory passages.

What is Chloralum?

The chloride of aluminium.

How may House Disinfection be effected?

By burning 4 lb of sulphur in every 1000 cubic feet of air space. By burning Formalin tablets (25 to 1000 cubic feet) in an Alformant Lamp. In both cases all crevices ought to be sealed and the rooms kept closed for several hours. Sulphur acts more efficaciously in a damp atmosphere. Trenner's Formaldehyde Disinfector may be employed for diffusing formaldehyde vapour through the keyhole. Lingners' Apparatus is also used for room disinfection. Both are vaporisers. In the case of Trenner's it is suggested to use 9 oz. of Formalin to 1000 cubic feet of air space. Other

gaseous disinfectants are SO_2 gas stored in a liquid condition under pressure. Chlorine gas and nitrous acid have also been employed.

What other Method is available for Room Disinfection ?

By means of a spraying apparatus whereby such a solution as formalin in the proportion of 6 oz. of a 40 per cent. solution to the gallon of water may be sprayed over presumably infected surfaces. Care must be taken to spray from below upwards to avoid streaking of wall and other surfaces. Corrosive sublimate may also be employed in the strength of 1-3000, but it has a tendency to cause salivation and traces of it are left behind on sprayed parts to the discomfort perhaps of the occupants of the disinfected house. For smallpox however and typhus it may be advantageous and expedient to employ the perchloride.

How may Clothing and Bedding be disinfected ?

Either by means of steam or by subjecting them to the influence of formalin, or sulphurous acid gas. In the latter case the articles would be hung over ropes or clothes horses and the gases generated in sealed apartments. This manner of disinfecting would only be performed in the absence of more up-to-date methods.

What are Different Varieties of Steam Disinfectors? Mention some Types.

Low pressure and high pressure. Of the low pressure forms the Thresh and the Reck are the best known. Of the high pressure apparatus the Equifex (Geneste Herscher), Washington Lyon and Goddard, Massey and Warner are the best.

What is the Definition of Low Pressure as compared with High Pressure Steam ?

Low pressure steam is generated at atmospheric pressure

and therefore at 212° F.—*e.g.* steam coming from the spout of a boiling kettle. High pressure steam is generated under pressure—*e.g.* a kettle with its lid clamped down and the spout blocked up would not permit of the escape of steam, consequently the steam would be generated under pressure.

What Influence has Pressure on Temperature ?

The greater the pressure the higher the temperature. For example, steam at no pressure has a temperature of 212° F. whereas steam at 10 lb pressure has a temperature of 240° F.

What makes for Success in Steam Disinfection ?

The expulsion of all air from the interior of the disinfecting chamber.

What are the Definitions of Saturated and Superheated Steam ?

Saturated steam is steam generated under pressure and in contact with the water which generates it. Superheated steam is steam heated beyond its temperature by coming in contact with a surface hotter than itself. Steam passing through a pipe heated to redness would be superheated because the pipe would be hotter than the steam. Superheated steam is dried steam ; in fact the steam is converted to a hot vapour.

How does Steam effect Disinfection ?

By parting with its latent heat. As the steam condenses on the articles to be heated a vacuum is formed layer by layer until finally the deepest reeesses are penetrated. Pressure steam acts more quickly than non-pressure steam.

What is the value of Superheated Steam ?

As a disinfectant it has little, if any, value, it is no better than a hot gas, it lacks the powers of penetration and scorches the clothing. Ransom's Hot Air Disinfector had the same drawbacks and was therefore discarded.

How would you disinfect Empty Rooms or Uninhabited Places?

After the patient has recovered (or died) and left the sick-room, it must be carefully disinfected (see page 35). Clothing and bedding should be removed to be disinfected by steam.

HEATING

What is the Principle of Warming by Steam?

The cold air surrounding the steam pipes rapidly condenses the steam, which, in being condensed, gives out its latent heat.

What do you mean by the Latent Heat of Steam?

The amount of heat which disappears in converting water at 212° F. into steam of the same temperature.

How much is this?

536 thermal units.

What becomes of this Heat?

It is given out when the steam is condensed, and it is this that heats the room.

What is the Surface Temperature of a Pipe filled with Steam at 212° F.?

About 200° F.

What Size of Pipe would you allow?

A pipe four inches in diameter.

How much Pipe is required?

Allow—

1 square foot for every 6 square feet of glass.
1 square foot for every 120 square feet of walls and roof.
1 square foot for every 6 cubic feet of air.

Is Air or Water more easily heated ?

Air : the amount of heat sufficient to raise 1 cubic foot of water one degree will raise 2850 cubic feet of air one degree.

How is the Condensed Water got rid of ?

There must either be a syphon used for taking it off, or else a float ball valve steam trap used.

If the Water were not removed, what might happen ?

The water would cause the steam to be condensed so rapidly that a vacuum would be formed in the boiler, and hence the boiler, unless it be specially strong, may be crushed in by atmospheric pressure.

What has to be attended to in Jointing the Pipes ?

Must allow room for expansion : cast-iron expands one-eighth of an inch for every 10 feet. LEAD must be used in jointing. The pipes should not be connected with any part of the building ; the horizontal ones should be laid on rollers to allow of free movement during expansion and contraction.

Is Steam much used for Heating ?

No ; it has long been superseded by hot water apparatus of various kinds.

What are the Varieties of Hot Water Apparatus ?

1. The Low Pressure.
2. The High Pressure.

THE LOW PRESSURE.—In this the water is at or below the boiling point : the pipes do not rise far above the boiler, and therefore the boiler and pipes need not be VERY strong : one pipe rises from the top of the boiler, traverses the places to be warmed, and returns to terminate near the bottom of the boiler. The boiler may be open or closed.

The High Pressure.—In this the water is heated to 350° F. and upwards, and is therefore constantly seeking to burst out as steam, with a pressure of 70 lb or more to the square inch, and therefore we must have a very strong or high pressure apparatus. The pipe is of iron, about 1 inch in diameter, and made very thick: the boiler should be very strong as every 34½ feet in height of pipe means 15 lb to every square inch of the interior of the boiler. The small strong pipes may be made to open into larger pipes in rooms or corridors, etc. Four-inch pipes are used for greenhouses, conservatories and hothouses; and pipes of 2 or 3 inches for churches, factories and dwelling-houses.

How much Air should be allowed for in Heating?

Allow 4 cubic feet of air to be warmed per minute for each person, and 1¼ cubic feet for each square foot of glass.

How much Air will a Cubic Foot of Water warm?

A pound of water in losing one degree will raise 4 lb of air one degree; but water is 770 times heavier than air, and a cubic foot of water in losing one degree will raise $770 \times 4 = 3080$ cubic feet of air one degree. A square foot of radiating surface of steam pipe is enough to heat 200 cubic feet of space.

Is it better to warm by Hot Water or Steam?

By hot water, as it takes five and a half times as long to drive water off as steam as it does to raise it from the freezing to the boiling point.

How does an Open Fire warm the Air?

The fire warms the walls and furniture, and these in turn warm the air, so that the walls are warmer than the air.

Compare Brick and Iron Stoves.

Brick stoves and flues are worse conductors of heat than iron ones, but the brick surface parts with heat more quickly than

an iron one. The slow conduction and greater thickness makes changes in the fire less felt and keeps hotter longer after the fire is out, and it does not spoil the air so much as an iron one. Iron stoves heat rapidly, and the effect is therefore unequal both on persons and on the air. They cool rapidly also, and carbonic oxide is formed if they are allowed to become too hot. It is better to line the iron stove with firebrick, as it equalises the effect on it better.

Whether is Cast or Wrought Iron worse?

The bad effects are three times as great in CAST IRON.

What are the Special Merits of Galton's Grate?

1. It ventilates the room.
2. It maintains an equable temperature at all parts of the room, and prevents draughts.
3. It throws more radiant heat into the room than other grates.
4. The firebricks keep the fire from going out, and prevent rapid changes of temperature in the room.
5. It economises fuel, it uses the spare heat, and ensures complete combustion.
6. It prevents smoky chimneys.

HOSPITALS

What is the best Site for a Hospital?

It should be in an airy open space, or at the outskirts of the city, and on a raised, dry, pure, porous soil.

What is the best Form of Hospital?

The pavilion style—*i.e.* a collection of small hospitals, connected by corridors—*e.g.* the Royal Edinburgh Infirmary.

The distance between the pavilions should be about twice the height of the pavilions. This allows of a free circulation of air round each pavilion.

How many Patients should be in each Ward?

From twenty-four to thirty-two on an average: there should be fewer in a surgical ward than in the medical. The number in a medical ward will depend more on the convenience of nursing than on anything else, but this is not the case in a surgical ward.

How much Cubic Space would you allow in a Hospital?

For an ordinary hospital, the usual figure is 1200 cubic feet; for infectious cases it should be from 2000 to 3000 cubic feet for each patient. In the ordinary medical wards in Edinburgh the space is 2220 cubic feet per head.

What should the Superficial Area be?

90 to 110 square feet for each patient. This space is necessitated for facilities of nursing and the conveniences of ward administration. The height of the ward should be about 14 feet, and its breadth 25 to 30 feet.

How should the Windows be arranged?

A window between each bed, and the space between each window should be about 6 feet 8 inches wider than the bed; they should be $2\frac{1}{2}$ feet from the ground and about 1 foot from the ceiling, and there should be a part at the top to open by sloping inward: the glass should be plate to economise heat. The windows at each side of the ward admit of cross ventilation by perflation.

How should it be heated and ventilated?

For fresh air inlets there should be a Sherringham valve near the ceiling between each window, or by a Tobin's tube. For heating, use Galton's Grate and hot water pipes. The gas

jets should have a bottomless lantern and extraction flue over each. The beds should be of iron and there should be as little furniture as possible.

How should the Water Closets, etc., be placed?

At the end in a little projecting tower, and shut off from the ward by moving doors and lobby with cross ventilation. Allow one closet for ten beds, or three for thirty-two.

What is the best Form of Floor for a Hospital?

Hardwood, polished and varnished, laid on concrete for the ground floor.

How many Beds should it contain?

Six beds for a population of 6000; it should not contain more than twenty beds.

How are the Wards divided?

Three beds in male ward.
Two beds in female ward.
And one ward used for operating-room.

How large should the Hospital for Infectious Diseases be?

One bed for every 1000 or 2000 persons in the town.

What Space should be allowed for Infectious Diseases?

The floor space should be from 144 to 170 square feet; the height as before, 14 feet; and the total cubic space, therefore, from 2000 to 3000 cubic feet. Smallpox and typhus cases require 3000 cubic feet.

1) What notifications are obligatory on the medical practitioner? [illegible] respectively [illegible] [illegible] and [illegible] notifications?

2) How may an epidemic [illegible] of [illegible] [illegible] the procedure to be adopted
(a) toward those attacked
(b) to prevent further spread of the disease.
(c) to ensure efficient disinfection

3) Describe briefly a system [illegible] purification of sewage [illegible] [illegible] chemical [illegible] have been found [illegible] take place [illegible] [illegible] disadvantages [illegible] the system, if any?

4) What are the principles of action of the [illegible] [illegible] [illegible] the [illegible]